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Science Education

The Science Magazine for All Science Teachers

Formerly General Science Quarterly

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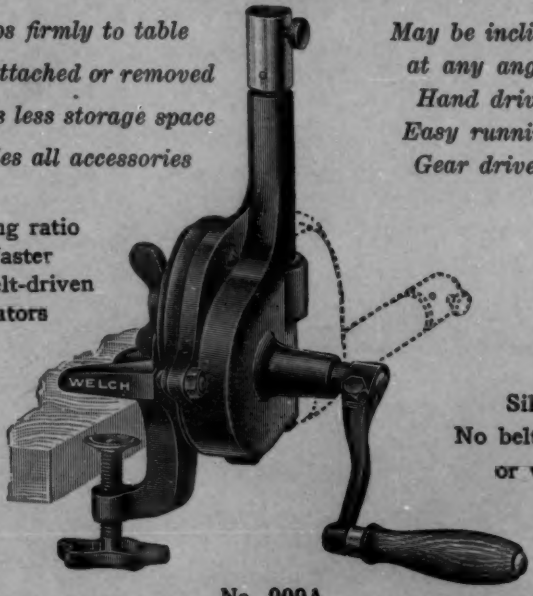

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WHY SCIENCE IS FUNDAMENTAL IN EDUCATION

"The best part of all human knowledge has come by exact and studied observation, made through the senses of sight, hearing, taste, smell and touch. The training of the senses should always have been a primary object in human education, at every stage from primary to professional.

The men who have done the most for the human race since the nineteenth century began, through the right use of their reason, imagination, and will, are the men of science."—*Dr. Eliot.*

Assimilation of the scientific method results in:

1. Accurate observation and straight seeing. That is fact-finding.
2. Exact and impartial reporting. That is fact-recording.
3. Careful reflection, precise and measured reasoning, and truthful attitude of mind that will give an honest reaction on the facts found. That is, "to think without confusion clearly" and be fact-facing and reality following.

Two dominant vices of our age are false values and wrong mental processes.

Although the material changes in man's environment have been greater in the last one hundred years than in all preceding historic time, few people appreciate that this acceleration is not necessarily progress. This prodigious material transformation is the result of the brains of a few, and, while it has greatly multiplied the power of the tortoise-minded masses, it has not increased their wisdom, nor fitted them to cope with the problems that the acceleration has produced. Our present intensive civilization rests on a multiplication of muscular effort by the utilization of energy resources, and is giving the equivalent of thirty servants to each person. This has revolutionized our standards of living, over-rated speed and under-rated sureness, complicated our social relationships, and created false values, thus making it more difficult for us to live and work together.

Few people can appreciate the distinction between facts and beliefs. At least one-half of our population lack sufficient brains to get through a high school or cope with the social problems of our age. Certainly less than 10 per cent of our people are capable of independent, creative thinking.

The scientific method, if used by many of our writers, would make them "say it with fewer words," and they would not pass so many good stopping places.

—*Samuel S. Wyer.*

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SCIENCE EDUCATION

Devoted to the Teaching of Science in Elementary Schools, Junior and Senior High Schools, Colleges and Teacher Training Institutions

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The Present Objectives in General Science

HENRY HARAP and ELLIS C. PERSING,
School of Education, Western Reserve University, Cleveland.

There is no study available at the present time which gives a complete and detailed inventory of existing objectives in the field of general science for the junior high school.[1] Our purpose, therefore, was first, to discover all the specific objectives in approved courses of study, textbooks, and curriculum investigations; and second, to assign to each, a measure of its frequency of occurrence in these sources. No attempt was made to organize them by grades or to validate them because we have no evidence to convince us that the *status quo* is an adequate basis for future courses in general science. However, we feel that our composite list of objectives, after the least important are eliminated, will yield a more dependable course of study than any now in use.

PROCEDURE

Selecting a Tentative List of Sources. Our first task was to select the sources of our objectives. We drew up a tentative list of curriculum investigations, courses of study, and text books. The curriculum investigations were limited to sound quantitative studies bearing upon the interests or needs of pupils between the ages of 11 and 16. The courses of study were those recommended by the Teachers College Bureau of Curriculum Research supplemented by others which, we were convinced, also should be included. The text books included practically all that were published in the last 10 years.

1 Since this was written, Mr. F. D. Curtis has published a study entitled, "A Synthesis and Evaluation of Subject Matter Topics in General Science," which is similar in scope but not in treatment.

Submitting the Tentative List of Sources to Leaders in General Science. This tentative list of sources was submitted to 13 leaders[2] in the field of general science with the request that they: (1) indicate which of our sources should be included in our study; (2) which should be excluded, and (3) which sources should be added. This resulted in the final selection of 21 publications: five curriculum studies, eleven courses of study, and five text books. The complete list of sources precedes the table of objectives given below.

Assembling the Objectives. Before proceeding to make the inventory we agreed on an interpretation of the term *objective.* To us the term means a specific goal expressed in terms of useful life situations. In determining how specific an objective should be we agreed that it should be concerned with a fairly small unit of life activity; that it should suggest a rather definite classroom activity; that it may be accomplished in a fairly short period of time; and that the achievement of it may be readily observed or measured. Since some of our sources failed to state objectives we were obliged to infer the author's implied goals from a reading of the context. When the source consisted of a bare list of topics we asked ourselves: "What is the child's objective suggested by the term?" Each objective was placed on a filing card, together with a key number indicating its source. This procedure yielded 1174 cards.

Sorting the Objectives under Main Headings. Obviously, it was impossible to treat the objectives in bulk. It was, therefore, necessary at this point to determine first, the main headings and second, the main divisions of general science, the latter being the more general. We looked especially for units of actual life activity. For this purpose we used two principle sources: (1) the section or chapter headings used in 12 textbooks of general science and (2) the science headings listed in Mr. Bobbitt's extensive study of the major activities of life.[3] The topics from Mr. Bobbitt's study yielded some which were not found in textbooks. Furthermore, after sorting the objectives we found a residue for which we had to assign additional headings. The main divisions were deter-

2 H. A. Carpenter; G. S. Craig; F. D. Curtis; C. W. Finley; E. R. Glenn; J. Hollinger; H. W. Le Sourd; M. Meister; C. J. Pieper; S. R. Powers; R. A. Waldron; W. G. Whitman, and H. A. Webb.

3 Bobbitt, F.—Curriculum Investigations, Chapters 1-6, University of Chicago Press, 1926.

mined by combining several related main headings into more inclusive natural fields of life. The list of main heading included air, clothing, heat, building materials, light, water, household equipment, weather, the earth and other heavenly bodies, soil, ores, and rocks, living matter, plant life, animal life, transportation, communication, industry, machines, sanitation and safety, foods, hygiene, recreation, and popular theories, principles and concepts. The main divisions included home, environment, living things, community, man, and popular theories, principles, and concepts.

The cards were first sorted under the main divisions such as *home* and *environment*. Then they were sorted under main headings such as *clothing* and *building materials*. Similar objectives were combined and counted. The frequency of occurrence was recorded and transferred to the table which is produced and discussed below.

There is some duplication of objectives which will be obvious to any reader of this paper, but we could not escape it because we were obliged to report the treatment given by the authors in their works. For example, *to understand the nature of a vacuum* is considered in connection with the study of the thermos bottle, but we were obliged to mention it separately under the heading of scientific concepts, because it was treated in isolation in two courses of study.

THE TABLE OF MAIN HEADINGS

We present below, a table of the frequency of objectives by main headings and main divisions. Certain conclusions are obvious at a glance. *Weather, industry, heavenly bodies*, and *heat* are the headings most frequently represented. *Building materials, recreation, popular theories* and *air* are least frequently represented. The single main division which is most frequently represented is *community*, followed by *home, environment, man, living things, and popular theories*. The table shows that courses of study are most heavily represented in the total results, furnishing over one-half of the objectives. The data from curriculum investigations furnished approximately one-sixth of the total number of objectives.

FREQUENCY OF OBJECTIVES UNDER EACH MAIN HEADING AS FOUND IN 5 INVESTIGATIONS, 11 COURSES OF STUDY AND 5 TEXTBOOKS

Heading	*Investigations*	*Courses of Study*	*Texts*	*Total*
Home	57	153	80	240
Air	3	16	7	26
Clothing	10	13	12	35
Heat	16	43	28	87
Building Materials	1	9	5	15
Light	8	28	14	50
Water	4	19	5	28
Household Equipment	15	25	9	49
Environment	53	144	55	252
Weather	19	66	33	118
Earth and Other Heavenly Bodies	26	50	12	88
Soils, Ores and Rocks	8	28	10	46
Living Things	18	61	18	97
Living Matter	1	19	6	26
Plant Life	10	20	7	37
Animal Life	7	22	5	34
Community	34	167	103	304
Transportation	9	34	24	67
Communication	4	26	15	45
Industry	11	54	31	96
Machines	1	28	22	51
Sanitation and Safety	9	25	11	45
Man	23	122	63	208
Foods	6	42	22	79
Hygiene	14	68	37	119
Recreation	3	12	4	19
Popular Theories, Principles and Concepts	5	15	3	23
TOTAL	190	662	322	1174

THE TABLE OF PRESENT OBJECTIVES

We present at the end of the paper what is the main contribution of this study — a table of the objectives found in the most satisfactory existing curriculum investigations, courses of study and textbooks. The introductory table gives a list of the sources used together with a key number for each source. The occurrence of an objective in any given source is indicated by a key number. Thus the reader knows not only the commonness of each objective, but also, in exactly what sources it occurs. The frequency of occurrence is given in four columns — investigations, courses of study, texts, and total — which makes it possible to make interesting comparisons. There were 275 objectives in the final table. The curriculum maker or teacher of general science can use this table in sev-

eral ways. He may wish to study it to get a convenient picture of the present situation in general science. Perhaps he will be sufficiently satisfied with these data to use the most common objectives as a basis for his reconstructed course. In comparing any given course with the table of objectives he may discover certain important omissions or overemphases.

CONCLUSIONS FROM A STUDY OF THE TABLES

We found many objectives stated too vaguely and broadly to be useful, for example, *to understand how electricity is generated and how it is applied to transportation* or *to know the factors of our environment.* Some objectives are stated abstractly, thus giving no clue as to the nature of their treatment. For example, sanitation is a home problem and a community problem, and unless the objective suggests definitely what should be learned, we are left in the dark.

Our list of sources represents the best investigations, courses of study and textbooks in the opinion of thirteen leaders in the field of general science. Certainly no curriculum-making group or teacher of general science can afford to ignore the references at the head of the table of objectives.

Twenty-five objectives discovered in the curriculum investigations do not appear in courses of study and textbooks at all. This warrants the conclusion that there is room for revision of the general science course. A comparison of the treatment of the several main divisions by the three types of sources reveals that texts treat *community* more extensively than courses of study. Texts do not appear to attach as much importance to *environment* as the investigations seem to warrant.

A comparison of the treatment of the main headings also reveals several interesting conclusions. The courses of study do not treat *clothing* as extensively as investigations seem to require but that may be due to its occurrence in other subjects. Courses of study place more emphasis on *water* than do the texts. Texts do not give as much attention to the *earth and other heavenly bodies* as the investigations seem to warrant and as the courses of study seem to demand. But, perhaps this material is adequately covered in earlier courses in geography and elementary science. Texts appear to be deficient in the treatment of *household equipment* when compared with the requirements of courses of study and the find-

ings of investigations. *Ores, rocks,* and *soils* are most heavily represented in the courses of study.

Texts do not treat *living things* as fully as courses of study require, but that is probably due to the common occurrence of biology in the tenth grade. Texts treat *communication, industry,* and *machines* a little more fully than our present investigations warrant, and the courses of study require. It is probable that in these fields, investigations have not been pursued far enough to give us an adequate idea of the needs.

The place of certain topics such as *communication* (159-164), *transportation* (141-158) and *machines* (189-200) is not yet completely established by objective evidence. The topic *living matter* in general requires supporting evidence before we can feel certain that it deserves treatment in texts and courses of study, especially since it is included in the tenth year where biology is commonly offered.

We are convinced that the field of general science as it is now constituted is in need of evidence to justify it. The amount of investigation thus far carried on is insufficient to establish the content definitely.

We were forcibly impressed with the need of establishing objectively the grade placement of the general science objectives. This includes the assignment of legitimate general science objectives within the junior high school grades; the elimination or random duplication of the objectives of science in the elementary grades; and the planful articulation with the science of the senior high school grades.

NEW STUDIES NEEDED

We are convinced that there is a need of an intensive study of grade placement in science for the twelve grades. A large number of the objectives presented here on the junior high school level commonly appear in elementary courses of study. When texts do not treat *ores, rocks,* and *soils* although some courses of study require that they be taught, is it because the authors assume that they should be covered in the elementary grades? When courses of study prescribe much work on *living matter,* do they anticipate the study of biology in the tenth grade? When textbooks and courses of study include *common trees, flowers* and *birds,* are they aware that they are commonly studied in the elementary grades? We do not

object to duplication, or rather repetition, *per se*. We do, however, insist that it should be deliberate and not haphazard.

At present there are not enough curriculum investigations to establish the content of general science objectively. They do not cover the whole field of science. For example, the division devoted to the home contains many objectives listed by Harap in his analysis of the activities of consumption, but only a comparatively few listed by Curtis and Pollock who studied the interests of pupils. On the other hand when we come to the division devoted to the environment outside the home we find practically no objectives from Harap's list and abundance of objectives from Curtis and Pollock's lists. We are inclined to believe, therefore, that the objectives in junior high school science will depend upon several analyses of the several fields of life which are related to science.

A beginning has been made in three fields of life — the field of consumption, the field of curious observation of the natural environment, and the field of interpreting common reading materials. The fields which are sadly in need of exploration include science in common conversation; newest popular, generally used mechanical developments; home experimentation; outdoor recreation; the performance of our daily duties; understanding the more important public services; interpreting popular principles or theories. For instance, it is reasonable to assume that certain popular scientific theories, principles, or facts, chiefly from the field of popular science, should be known by the layman. They enter into the conversation of fairly cultivated persons but, what is more important, they frequently have much to do with the course of progress.

As an illustration of the new investigations needed one might use the following procedure. First, ask librarians, writers of popular science, and a few scientists to submit titles of important popular works in science. From the collection select 20 of the most important. Second, analyze each book for principles, theories, and facts. Arrange these under convenient headings and record their frequency. Third, submit the list of principles, theories, and facts to 50 intelligent adults, asking them to check those which interest them. Fourth, make the final selection of objectives from the combined score of frequency of occurrence in books and frequency of choice by adults.

The elements of science in the more important daily duties can be ascertained by interviewing a large number of adults to determine what they would like to know about each of a comprehensive list of topics that would help them to perform their daily tasks more effectively. The most popular mechanical developments such as the airplane and television can be ascertained by a study of the census of manufactures for their financial significance and the scientific journals for their technical importance.

Some of the more common experimental activities in the home can be ascertained by a canvass of a large number of adults and adolescents from good homes. Elements of science in the outdoor recreation of youths and adults can be discovered by an analysis, from the viewpoint of science instruction, of existing studies of recreational activities or by making original investigations. The scientific facts necessary to understand the more important public services can be discovered by an analysis of the most widely circulated public documents, such as the President's message to Congress, platforms of political parties, the city record, and so on.

CONCLUSION

We undertook to discover the present objectives of junior high school science. From a carefully selected list we assembled specific objectives and recorded them in a table, showing the most common objectives found in curriculum investigations, courses of study, and textbooks. A study of the table yielded many interesting conclusions, the most significant of which is that there is a great need of further original analyses to discover the specific useful objectives of junior high school science.

SOURCES OF PRESENT OBJECTIVES (SPECIFIC) IN JUNIOR HIGH SCHOOL SCIENCE

CURRICULUM INVESTIGATIONS

Key No.

1. Bobbitt, F.—*How to Make a Curriculum*, Houghton Mifflin, 1924. pp. 129-145.
2. Curtis, F. D.—*Some Values Derived from Extensive Reading of General Science.* Teachers College, 1924, pp. 10-27.
3. Curtis, F. D.—*Some Values Derived from Extensive Reading of General Science.* Teachers College, 1924, pp. 27-40.
4. Harap, H.—*The Education of the Consumer*, Macmillan, 1924, pp. 324-330.

5. Pollock, C. A.—Children's Interests as a Basis of What to Teach in General Science. *Ohio State University Educational Research Bulletin, January* 9, 1924.

COURSES OF STUDY

11. Austin, Texas—*Course of Study in Science*, 1925. (Grades Eight to Ten.)
12. Denver, Colorado—*General Science, Grades Seven to Eight*, 1924.
13. Los Angeles, California—*General Science*, Course of Study, Monograph No. 26, June 1923.
14. Pittsburgh, Pa.—*High School Course of Study in General Science, Junior Division, Grades Seven to Nine*...1927.
15. Missouri State Teachers Association—*General Science Syllabus*, 1925.
16. Princeton, N. J.—*Elementary Science, Grades Seven to Nine.* 1926-7.
17. St. Louis, Mo.—*Science for Grades Seven, Eight and Nine*, 1926.
18. New York State—*Syllabus in General Science*, 1926. (Constructed for three years.)
19. Minnesota, State of[4]—*High School Curriculum and Syllabi of High School Subjects.* General Science and Biological Science, 1925. (Grades Nine and Ten.)
20. Oakland, Cal.—*Handbook of Science, Grades Seven, Eight and Nine*, 1925.
21. New Jersey, State of—*Course of Study in Physical Science, Grades Seven, Eight and Nine*, 1927.

TEXTBOOKS

31. Caldwell, O. W., and Eikenberry, W. L.—*Elements of General Science*, Ginn and Co., 1926.
32. Clements, A. G., Collister, M. C., and Thurston, E. L.—*Our Surroundings*, The Iriquois Publishing Co, 1928.
33. Pieper, C. J., and Beauchamp, W. L.—*Everyday Problems in Science*, Scott, Foresman and Co., 1925.
34. Van Buskirk, E. F., and Smith, E. L.—*The Science of Everyday Life*, Houghton Mifflin Co., 1925.
35. Webb, H. A., and Didcot, J. J.—*Early Steps in Science*, D. Appleton and Co., 1927.

The Present Objectives in General Science

(Based on a Study of Twenty-one Sources)

No.	OBJECTIVES	FREQUENCY BY KEY NUMBER			
		Investigations	Courses of Study	Texts	Total
	HOME				
	AIR (Ventilation)				
1	To become acquainted with methods of ventilating and know the relative value of each	3–4	11–12–13 14–15–17 21	31–32–33 34–35	14
2	To humidify the air	4	15–19		3
3	To determine the relative humidity		18–19–21	31–32	5

4 This is the only source that did not treat "man." The course in general science is planned for one year, the ninth. Biology is offered in the tenth year.

No.	OBJECTIVES	FREQUENCY BY KEY NUMBER			
		Investigations	Courses of Study	Texts	Total
4	To know the noxious presences in the air and how to offset them		11–17–19 21		4
	CLOTHING				
5	To understand the purpose of clothing	4	11–14	34	4
6	To care for the clothing properly	4	11–12–14 16–17–19 20–21	31–33–34 35	13
7	To identify the fibers used for clothing and know the relative value of each	4	14–21	33–34–35	6
8	To understand ancient methods of spinning and weaving			33	1
9	To know how thread is numbered			35	1
10	To know the action of bleaching powder		21		1
11	To distinguish the various kinds of leather and to know the relative value of each	4			1
12	To purchase and care for shoes properly	4			4
13	To identify the various kinds of fur and know the relative value of each	4			1
14	To use household dyes	4–5		35	3
15	To know why dyes fade			35	1
16	To know how artificial light affects colors, in the purchase of materials	4			1
17	To know how sunshine and heat affect rubber fabrics	4			1
	HEAT				
18	To heat our homes properly	3–4–5	11–12–15 16–20–21	33–35	11
19	To know how the home is heated by electricity		11–19		2
20	To use hot air properly for heating		17–19–21	31–32–33 34	7
21	To use hot water properly for heating	3	21	31–32–33 34–35	7
22	To use steam properly for heating	3–5	19–21	31–34	6
23	To use oil properly for heating		12–19	34	3
24	To use the fire-place properly for heating		19	32–34	3
25	To know the nature and value of the common fuels	2–3–4–5	11–12–14 16–17–18 19–21	32–33–34	15

No.	OBJECTIVES	FREQUENCY BY KEY NUMBER			
		Investigations	Courses of Study	Texts	Total
26	To understand the nature of fire and to prevent damages by fire	3–4–5	11–12–16 17–18–19 20–21	32–33–34	14
27	To understand the nature of heat and how it is measured	3–4–5	11–12–13 17–19–21	31–32–34 35	13
28	To understand the use of the chimney		17–19	31–32	4
29	To know the early methods of heating		14–17		2
	BUILDING MATERIALS				
30	To know the most suitable type of home for the location and need		14–16–17		3
31	To know how homes are planned		14	34	2
32	To know the nature of various building materials and the relative value of each	4	16–17–21	34–35	6
33	To know how raw materials are prepared for building purposes		21	33–35	3
34	To know how glass is used		21		1
	LIGHT				
35	To illuminate the home properly	2–4	11–12–13 14–15–16 18–19–20 21	31–34–35	15
36	To care for the lighting equipment	4	15–16	31–33	5
37	To know the nature of the illuminants and how they are used	4	11–14–17 18–19–21	31–32–33	10
38	To know the comparative costs of using various illuminants	4	11–14	31–33–34 35	7
39	To know the nature and properties of light	5	12–19–21	31–32	6
40	To understand the effect of colored surroundings on light	4–5	15–19		4
41	To know the benefits derived from light		11–21		2
42	To know how light is measured		21		1
	WATER				
43	To know the source of the home water supply	5	15–16–17 19–21	31–34	8
44	To care for and maintain the home water system	4	11–12–13 15–21	34	7

No.	OBJECTIVES	FREQUENCY BY KEY NUMBER			
		Investigations	Courses of Study	Texts	Total
45	To keep the home water supply from becoming contaminated	4	18–19–21	34	5
	To determine the cost of the home water supply		15–21		2
47	To know the uses and importance of the home water supply		17–18–19 21	32	5
48	To be familiar with the drainage systems in the home	4			1
	HOUSEHOLD EQUIPMENT				
49	To select, use and care for household electrical equipment	3–4–5	12–15–16 17–20–21	31–32–33 34–35	14
50	To estimate the cost of operating electrical equipment	4	16–20		3
51	To select and use suitable cleansers and know the relative value of each	4–5	11–12–19 20–21	32–34	9
52	To know how the home is kept sanitary	3–4–5	19		4
53	To select and care for house furnishings	4–5	20–21		4
54	To care for musical equipment in the home	2–4–5	15–16–17		6
55	To care for and beautify the home garden	4	11–14–16 17–18–20	34–35	9
	ENVIRONMENT				
	WEATHER				
56	To know the factors influencing weather	3	11–15–16 17–18–21	31–32–35	10
57	To understand the methods of predicting weather	3–5	12–13–15 16–17–18 19–20–21	31–32–34	14
58	To know the effect of weather on living things		12–16–18	33–34	5
59	To know the construction and purpose of the barometer		11–18–10 21	31–32–34 35	8
60	To make a barometer			31	1
61	To know the forms of precipitation and how they occur	2–3–5	11–12–16 17–18–19 21	31–33	12
62	To measure rainfall	3	13–21	32	4
63	To know the properties of water and its composition		11–22–18 19–21	31–32–34	8
64	To know the properties of air and its composition	3–5	11–12–13 15–16–17 18–19–21	31–32–33 34	15
65	To know the kinds of clouds and their formation	2–5	11–19–21	32	6

No.	OBJECTIVES	FREQUENCY BY KEY NUMBER			
		Investigations	Courses of Study	Texts	Total
66	To know what causes the change of seasons	5	11–12–18 19–21	31–33	8
67	To know what winds are and how they are caused	2–3–5	11–13–15 16–18–19 21	31–32–33 34	14
68	To measure wind velocity		21		1
69	To know the causes and effect of lightning	2–5		32	3
70	To know how thunderstorms occur	2	19–21	35	4
71	To understand the rainbow	5	21		2
72	To know why weather changes usually occur from the west in the greater part of the U. S.			33	1
73	To be acquainted with the work of the Weather Bureau		21		1
74	To construct a weather vane		21		1
	THE EARTH AND OTHER HEAVENLY BODIES				
75	To understand the heavens as a whole		18	35	2
76	To know the nature of the stars	2–5	14–17–19 21	31	7
77	To identify stars and constellations	3–5	12–16–17 19–21	32–33–34	10
78	To understand the force of gravity	2–5	21		3
79	To know the nature of the solar system	2	11–12–13 14–16–18 19–20–21	32–33–34	13
80	To know the planets	2–5	11–12–19 21	31	7
81	To know the nature of comets	5	11–12–21		4
82	To become familiar with the nature and effect of the sun	2–5	11–12–14 16–17–18 21	33–35	11
83	To know the nature of the moon	2–5	12–14–21		5
84	To understand eclipses	5			1
85	To know the important facts about meteors	2			1
86	To know about geysers	2–5			2
87	To know about glaciers	5			1
88	To understand the earth's magnetism		12–21		2
89	To know the effect of the heavenly bodies on our welfare		18	35	2
90	To know about latitude and longitude and how to use	5	12–16–19 21		5

No.	OBJECTIVES	FREQUENCY BY KEY NUMBER			
		Investigations	Courses of Study	Texts	Total
	them				
91	To know what the northern lights are	5			1
92	To know the causes and actions of volcanoes	2–5	19		3
93	To know the causes of earthquakes	2–3–5			3
94	To know how an astrolabe is constructed		21		1
95	To know how telescopes are constructed and used		21		1
96	To know how a seismograph is used		21		1
97	To know how modern astronomy developed		21		1
98	To know the action of glaciers		19		1
	SOIL, ORES, AND ROCKS				
99	To know the composition and formation of the earth's crust	5	11–12–13 14–16–17 18–19–21	31–32–34 35	14
100	To know the relation of soil to life		11–16	31	3
101	To know the effect of water on soil		16–21	31–35	4
102	To know why crystals form	3	21		2
103	To understand the effect of pressure	3			1
104	To know the nature of metals and the relative value of each	3–5	11–12–21		5
105	To know the nature of elements and compounds		21	34	2
106	To know the nature and composition of matter		21	32	2
107	To know the nature of carbon		11	32	2
108	To know the nature of chalk	5			1
109	To know the nature of phosphorous		11		1
110	To know the nature of salt		11–21		2
111	To know the nature of sulphur		11–21		2
112	To know about nitrates	3			1
113	To know why asbestos does not burn	5			1
114	To know how coal is formed		21		1
115	To know how rocks and soils were formed		19–21		2

No.	Objectives	Frequency by Key Number			
		Investigations	Courses of Study	Texts	Total
	LIVING MATTER				
116	To know the most important common characteristics of living things		11–12–14 15–18	32–34	7
117	To know the relation of living things to environment		12–14–16 17–18	31	6
118	To know how living things are improved		14–20–21		3
119	To know the inter-relation-of living things		12–14–21	31–32	5
120	To know how living things differ from non-living		12–21		2
121	To know the causes of decay			31	1
122	To know what a fossil is	3	21		2
	PLANT LIFE				
123	To know the nature and structure of plants	3–4–5	13–17–18 20–21	31–32–34 35	12
124	To know the needs of a growing plant	3–4–5	11–16–17 20–21	31–35	10
125	To identify common trees and other plants	2–3–5	14–17–21		6
126	To know the economic value of trees and other plants		12–14–16 18–21	32	6
127	To understand how forests are developed and protected		14		1
128	To identify and know the economic value of evergreens	3			1
129	To plant a tree		18		1
	ANIMAL LIFE				
130	To know the nature of animal life		20–21	31–32–35	5
131	To identify some common animals and know their relative economic value		12–13–14 16–19–20		7
132	To identify common insects and know their relative economic value	3–5	11–16–17 18–21	31–35	9
133	To identify and know the habits of common local birds	2–5	14–17		4
134	To cultivate an interest in pets and become familiar with important facts about them	2	21		2
135	To know the most interesting facts about fishes	2			1
136	To distinguish between harmful and harmless snakes	2			1
		2			1

No.	OBJECTIVES	FREQUENCY BY KEY NUMBER			
		Investigations	Courses of Study	Texts	Total
137	To care for an aquarium		16–21		2
138	To attract birds		20		1
139	To know some prehistoric animals		21		1
140	To classify animals according to food habits		21		1
	COMMUNITY				
	TRANSPORTATION				
141	To know some simple facts about land transportation		21	32–33–34	4
142	To know how roads are built	1		35	2
143	To be familiar with the construction, operation and upkeep of the automobile	4	12–14–21	31–33	6
144	To understand the construction and operation of railroads		14–17–21	33–35	5
145	To understand the problems of transportation by water		14–19–21	31–32–34 35	7
146	To know why ships float	5	19–21	31–33	5
147	To know how ships are steered and propelled		21	33	2
148	To know the principle of the submarine	5	19–21		3
149	To make a diving bell		11–21		2
150	To understand the nature of the compass	5	21	32–34	4
151	To understand the nature of airplanes and dirigibles	3–5	11–12–16 19–21	31–32–33 34–35	12
152	To understand the relationship between electricity and transportation		11–14–21		3
153	To understand inventions underlying transportation		20		1
154	To understand the hygiene of transportation			35	1
155	To know how tunnels and subways are used	1	21		2
156	To know how bridges are constructed	1	21		2
157	To know the importance of streams and other bodies of water		16–19–21		3
158	To understand the nature of the gas engine and its uses		11–16–19	31	4
	COMMUNICATION				
159	To understand the history and development of communication		14–17	34	3

No.	OBJECTIVES	FREQUENCY BY KEY NUMBER			
		Investigations	Courses of Study	Texts	Total
160	To know the nature of sound	2–5	11–12–13 17–18–19 21	32–35	11
161	To know how electricity is related to communication		11–15	31–35	4
162	To know the principle of the telephone	5	12–14–16 19–21	31–32–33	9
163	To know the principle of the telegraph		12–14–16 19–20	31–32–33	8
164	To know the principle of the radio (wireless communication)	3	12–14–19 20–21	31–32–33 34	10
	INDUSTRY				
165	To know what work is		11–18–19 21	34	5
166	To know how work is measured	3	11	32–33	4
167	To know how work is hindered		11–18–19 21		4
168	To know how primitive man worked		12		1
169	To understand the nature of water and its use as a source of power	4	11–12–16 18–19–21	32–33–34	10
170	To understand the air as a source of power		11–12–18 19–21	32–33–34	8
171	To understand the production and use of electricity as a source of power	2–3	11–12–13 16–17–21	31–32–33 35	12
172	To understand the steam engine as a source of power	5	11–16–19 21	31–33–35	8
173	To understand the use of heat in industry		18		1
174	To understand the nature and forms of energy	3–5	12–16–17 18–21	31–32–33 34	11
175	To understand how air enables man to work under water		19	33	2
176	To understand the value of agriculture as the basis for other industries		18–21		2
177	To understand how farm crops are grown		14–17		2
178	To know the importance of the potato industry		14		1
179	To understand irrigation		12–19	31	3
180	To understand a dairy		14		1
181	To understand the importance and value of forestry		18–21	31–32	4
182	To know how paper is made	4–5	12–21		4
183	To know how glass is made	5	21	33–35	4
184	To know how ice is made			31–32	2

No.	OBJECTIVES	FREQUENCY BY KEY NUMBER			
		Investigations	Courses of Study	Texts	Total
185	To understand how clothes are made		21	35	2
186	To know how leather is made		21	35	2
187	To understand electroplating and electrotyping		19	32	2
188	To understand the nature and action of steel	3			1
	MACHINES				
189	To know the principles and uses of simple machines		11–13–15 16–17–18 19–21	31–32–33 34–35	13
190	To understand complex machines		11–19–21		3
191	To know the care of machines		14–21	33	3
192	To understand keeping time with a machine			35	1
193	To know the law of Conservation of Energy		16–21		2
194	To know the principles of the water-wheel	3		32	2
195	To know how a magnet operates		13–16–19 21	31–32–34	7
196	To know the principle of the dynamo		19–21	32–33	4
197	To know the principle of the electric motor		19–21	32–33	4
198	To understand the nature of electric cells		21	32–33–34	4
199	To know the principles of pumps		19–21	31–33–34	5
200	To know the principle of the siphon		19–21	34	3
201	SANITATION AND SAFETY				
201	To know the source and care of the water supply	1–4–5	11–12–13 14–15–18 19–20–21	33–34–35	15
202	To understand the methods of sewage disposal	1	16–17–18 19	32–34–35	8
203	To understand the methods garbage disposal		16–17–18 19		4
204	To know how air is polluted	5	12		2
205	To know how to dispose of wastes			31	1
206	To know how water is purified		11–15–16	33–34	5
207	To have a citizen's knowledge of the ice supply	1	19		2

No.	OBJECTIVES	FREQUENCY BY KEY NUMBER			
		Investigations	Courses of Study	Texts	Total
208	To understand how to protect the community from common diseases		18	35	2
209	To have a citizen's knowledge of ventilating public buildings	1			1
210	To understand the work of health agencies		19–20		2
211	To understand fire protection	1		35	2
212	To have a citizen's knowledge of street lighting	1			1
	MAN				
	FOODS				
213	To understand the selection and preparation of foods	4	11–12–15 16–17–18 20–21	32–33–34	12
214	To know the composition of foods	4–5	11–14–15 17–21	32–34	9
215	To know the sources of foods	4	12–17–21	31–33–34	7
216	To know the care and conservation of foods		11–12–14 17–18–19	33–34	8
217	To know the food requirements of the body		12–15–16 17–18–21	33	7
218	To know how the body uses foods	5	16–17–18	31	5
219	To form correct eating habits		15–20–21		3
220	To know the process and hygiene of digestion		11–14–17 20	31–32–33 34–35	9
221	To know the nature and effects of stimulants			31–32–33	3
222	To know the nature and effects of narcotics		17–20	32	3
223	To understand the uses of yeast	5	11–21	31	4
	HYGIENE				
224	To prevent and control disease	3	12–15	33	4
226	To understand the causes of disease	3	14–19–20 21	32–33–34	8
226	To know the relationship of bacteria to disease	3–5	11–14–15 16–17–18 19–20–21	32–33–34 31	15
227	To know the relationship of air to health	2–5	11–12–14 15–17–19 21	31–32	11
228	To know the relationship of weather to health		16–19	31–35	4
229	To know the relationship of water to health		11–19–21	31–35	5

No.	OBJECTIVES	FREQUENCY BY KEY NUMBER			
		Investigations	Courses of Study	Texts	Total
230	To know how clothing affects health	4–5	15	33–34	5
231	To understand the care and function of our eyes	5	11–12–13 15–17–18 19–20–21	31–32–33 34	14
232	To understand the function and care of our ears		11–12–19	31–32	5
233	To understand the nature of the voice		11–21		2
234	To know how the teeth are formed	5			1
235	To know the function and care of our nervous system		14–16–20	32–35	5
236	To understand the process of respiration		14–21	32–33	4
237	To be acquainted with the excretory system		14	32	2
238	To know why our body requires care		12–20–21	32–33–35	6
239	To understand circulation		14–21	34	3
240	To know some poisons		21		1
241	To know the most important bones of the human skeleton		14	32	2
242	To know the functions of the muscles		14	32	2
243	To give first aid	4	16–20	32–33–34	6
244	To protect the body against extreme frost and heat		15		1
245	To know how to reduce		15		1
246	To know the effects of drugs on the body	5	11		2
246	To know how anesthetics act	5			1
248	To understand patent medicine claims		17–20		2
249	To give intelligent care to the baby		20		1 1
250	To know where the baby comes from		20		1
251	To work at a temperature of 65° to 68° F.		15–19–21		3
252	To understand facts about heredity	5	14	31	3
	RECREATION—OUT- AND IN-DOORS				
253	To use and understand the action of firearms	5			1
254	To make picnic fires		16		1
255	To know how to fish	5			1
256	To know the recreational value of forests		16		1

No.	OBJECTIVES	FREQUENCY BY KEY NUMBER			
		Investigations	Courses of Study	Texts	Total
257	To use and understand the principle of photography	5	11–12–13 17–21	35	7
258	To know how to swim		21		1
259	To know how to skate		21		1
260	To understand how a motion-picture projector is operated			35	1
261	To understand the nature of the phonograph		12–19–21	31–35	5
	POPULAR THEORIES, PRINCIPLES AND CONCEPTS				
262	To know the theory of evolution	2–5	21		3
263	To understand the origin of life		21	34	2
264	To know how the earth was formed	2	21	33	3
265	To know the relation of the earth's history to the history of life		20		1
266	To know and understand the work of some great scientist		18	32	2
267	To know what evidence there is for believing planets to be peopled	2	21		2
268	To know why X-rays penetrate solids	3			1
269	To rate newspapers and magazines as to reliability of scientific news		20		1
270	To know and use the metric system		20–21		2
271	To define the term "science"		21		1
272	To prove matter exists		21		1
273	To know how distances are measured in the universe		21		1
274	To know what a vacuum is		19–21		2
275	To know how to weigh		21		1

An Analysis of the Scientific Background of Students Enrolled in Courses in Science for Teachers in Elementary Schools[1]

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A course in science for teachers in elementary schools is well established in teacher-training institutions in the United States. This is indicated by a survey of the catalogues of 198 teachers colleges and normal schools located in forty-one states. The catalogues of these institutions for the academic years 1927-1928 and 1928-1929 show that 146 offer some type of course designed primarily for teachers in elementary schools. Such a course is required in 106 of these schools in one or more of their curricula.

To secure knowledge regarding the background of information in natural science of students enrolled in courses in science for teachers in elementary schools, a study was made of the scientific preparation of 954 students enrolled in such courses. Information concerning this preparation was secured in the following ways:

1. By a test of range of information in science.
2. By the science courses studied by the individual students.
3. By the courses listed as prerequisites in the catalogues of teacher-training institutions.

The Powers General Science Test, Forms A and B, was used to give data concerning the range of information in science possessed by the students. The science departments of fourteen teacher-training institutions cooperated in giving the test to their students. These schools were located in the various sections of the country as follows:

4 schools in the Eastern States
4 schools in the Central States
3 schools in the West Central States
3 schools in the Western States.

The data from the fourteen schools show wide individual and group variation in information possessed by the students concerning the various items on the Powers General Science Test. On Form A the class range is from eight to eighty-three

1 A detailed report of this paper is given as a part of the study by Florence G. Billig, "A Technique for Developing Content for a Professional Course in Science for Teachers in Elementary Schools." Teachers College, Columbia University, Contributions to Education, No. 397, 1930.

inclusive, and on Form B from five to eighty-six inclusive. On Form A the mean for the different schools ranges from 35 to 54.44, showing a difference of 19.44 points and on Form B the range is from 27.69 to 59.44, showing a spread of 31.75 points.

By a comparison of the data from the Powers test, Forms A and B, with the norms[2] for high school students on the same test, it is found that the mean for the students enrolled in courses in science for teachers is 6.67 points lower on Form A and 3.66 points lower on Form B than the corresponding norms for high school students who had been given the test immediately following instruction in general science for one year.

The 954 students gave information concerning their training in science before entering the teacher-training course in science. Of the students reporting, 946 or 99.16 per cent have studied some science course before entering the course for teachers. These students reported having studied seventeen different sciences listed in order of frequency in the following table:

TABLE I. *Per cent of Students Who Have Studied Each Science in High School Only, in High School and College, and in College Only.*

NAME OF COURSE	*Per cent of Students Studying*			
	High school course only	Both high school and college course	College course only	Total
General Science	54.19	..	.73	54.92
Biology	37.11	9.96	6.49	53.56
Physics	41.40	.10	1.05	42.55
Chemistry	40.67	.21	.94	41.82
Hygiene	15.30	.32	13.73	29.35
Agriculture	15.30	.21	11.11	26.62
Botany	21.06	..	1.26	22.32
Human physiology	10.90	.10	2.94	13.94
Physiography	7.44	..	.84	8.28
Zoology	7.44	..	.63	8.07
Astronomy	.42	..	1.15	1.57
Geology	.73	..	.52	1.25
Gardening	.42	..	.63	1.05
Bacteriology	.21	..	.21	.42
Nature Study	..	..	.21	.21
Anthropology	..	..	.10	.10
Anatomy	..	..	.10	.10

2 Powers, S. R. Directions for Giving Powers General Science Test. New York: Bureau of Publications, Teachers College, Columbia University.

Of these seventeen sciences, ten — general science, biology, physics, chemistry, hygiene, agriculture, botany, human physiology, physiography, and zoology — have each been studied by eight per cent or more of the students.

Figure 1 gives the above data in graphic form.

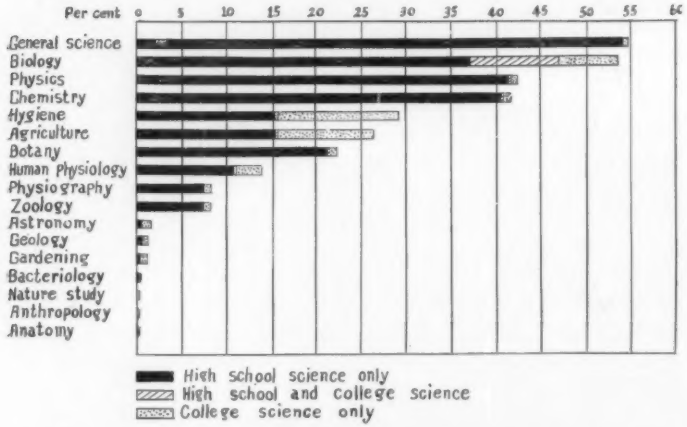

Figure 1. Percent of the 954 students who have studied each of the seventeen sciences in high school only, in high school and college, and in college only.

A further study of the data shows that general science has been studied by 54.92 per cent of the students; biology by 53.56 per cent; physics by 42.55 per cent; and chemistry by 41.82 per cent. These four sciences — the subjects most commonly reported by the students — are predominately high school courses. Botany, human physiology, physiography, and zoology have also been studied largely as high school courses. Agriculture and hygiene have been studied by an almost equal number of students in high school and college. The study shows that 9.96 per cent of the total number of students have studied biology in high school and have studied a course in college also. Courses in physics, chemistry, hygiene, agriculture, and human physiology studied in high school show but a slight amount of repetition in college.

Of the students who are enrolled in courses in science for teachers in elementary schools, 98.74 per cent have had some previous training in science in high school. Of these students 55.03 per cent have studied high school science only. In addi-

tion to the 55.03 per cent, 43.71 per cent of students have studied some high school and some college science. An analysis of the science courses offered by the 43.71 per cent of students shows that they are predominately high school courses.

The data from the study show that the number of science courses studied by each student varies. Eight students did not report having studied a science course while one student reported having studied nine. The analysis shows that 74.34 per cent of the students have studied two, three, or four courses in high school and college.

Since the science preparation of the students has been secured mainly in the high school, an analysis was made of the high school courses offered. When only one course has been studied, chemistry, physics, biology, general science, and botany are offered more often than other sciences.

The 294 students having studied two courses in science in high school offer thirty-nine different combinations. The combinations most commonly offered in order of frequency are as follows:

General science.....biology
Physics.....chemistry
Physics.....biology
General science.....chemistry
General science.....physics
Chemistry.....biology

The 248 students having studied three science courses in high school offer sixty-two different combinations. The combinations most frequently offered are as follows:

General science.....biology.....chemistry
General science.....biology.....physics
General science.....biology.....hygiene
Biology.....physics.....chemistry
General science.....physics.....chemistry

When combinations of two or more sciences are offered, the subjects usually combined are general science, biology, physics, and chemistry. These are also most commonly offered when only one science has been studied.

The data show that only 54.19 per cent of the students enrolled in courses in science for teachers have studied general science in high school; only 41.40 per cent have studied physics; only 40.67 per cent have studied chemistry; and only 37.11 per cent have studied biology. This means that no one high school science has been studied by more than 54.19 per

cent of the students. This fact is of importance in planning a course in science for teachers. It indicates that there is no body of knowledge in science which the instructor in the teachers college can expect all of the students to possess when they enter the course.

The length of time the various courses in science have been studied shows wide variation. Four courses — one in botany, one in zooolgy, one in human physiology, and one in physiography—were reported as one month in length. The students reported having studied 431 courses for a period of ten months. The data show that general science, biology, physics, and chemistry are predominately courses extending over a period of one year.

Courses listed by the teacher-training institutions as prerequisites for courses in science for teachers in elementary schools play an almost negligible part in determining the preparation of prospective teachers. Only eight courses listed by the 146 teachers colleges and normal schools offering science courses for teachers in elementary schools have prerequisites. These eight courses are listed by six institutions.

The results of this study may be summarized as follows:

1. The students show wide individual and group variation in knowledge relating to the items emphasized in Powers General Science Test, Forms A and B. The data show that the students are less well informed about the particular items of the test than are high school students who had been given the test immediately following instruction in general science for one year.
2. The preparation in natural science of the 954 students also shows wide variation:
   a. Seventeen different science courses are offered by the students. Of these courses general science has been studied by 54.92 per cent of the students; biology by 53.56 per cent; physics by 42.55 per cent; and chemistry by 41.82 per cent. The other thirteen science courses have been studied by 29.35 per cent or less of the students.
   b. There is wide variation in the number of courses studied by each student. One course was offered by 8.7 per cent of the students while 74.32 per cent

offered two, three, or four courses. There was found to be a small but consistent increase in the mean obtained on the Powers General Science Test, Forms A and B, with each additional science course studied.

c. Wide variation is shown in the particular science courses offered by the students. The courses most commonly offered, whether as single subjects or in combination of courses, are general science, physics, chemistry, and biology.

d. The length of time the various courses have been studied ranges from one month to one year. General science, physics, chemistry, and biology — the sciences most commonly offered — are predominately one-year subjects. Since these subjects are the ones most commonly offered by students entering teachers' courses in science, it is of importance that they extend over a period of one year.

e. Of the entire group of students reporting 55.03 per cent have studied high school science only previous to their enrollment in the course for teachers. This means that the instructors in the teachers colleges and normal schools depend upon the high schools for all of the scientific preparation which is possessed by 55.03 per cent of their students. In addition, the courses studied when both high school and college sciences have been offered are largely high school courses. These data show clearly that the preparation of the students entering courses in science for teachers in elementary schools is predominately high school science. It is this science preparation that the instructor must consider in determining the type of professional course to be offered in the teacher-training institution. No single high school course has been offered by more than 54.19 per cent of the students. The data show no sequence of science courses in high school which points toward a preparation for the work which the students expect to do.

3. Teachers colleges and normal schools are not requiring previous college training in science for admission to the course for teachers. A study of the catalogues of 198

teacher-training institutions show that 146 offer one or more courses in science for teachers in elementary schools. Of the courses offered by these schools only eight have prerequisites. The course for teachers in elementary schools is the first college course in science that a large majority of the students have studied. Since 71.07 per cent of the students enrolled in such courses in fourteen of these institutions are freshmen, they have had little opportunity to study science in college.

From this study it seems clear that the scientific preparation which the students bring with them from the high school composes the only background in science on which the instructors in teachers colleges and normal schools can rely as a basis for a professional course in science for teachers in elementary schools.

The Bloodless Sportsman

I go a-gunning, but take no gun;
I fish without a pole;
And I bag good game and I catch such fish
As suits a sportsman's soul.

For the chiefest game that the forest holds,
And the best fish of the brook,
Are never brought down by a rifle shot,
And are never caught with a hook.

I bob for fish by the forest brook,
I hunt for game in the trees,
For bigger birds that wing the air,
Or fish that swim the seas.

A rodless Walton of the brooks,
A bloodless sportsman, I.
I hunt for the thoughts that throng the woods,
The dreams that haunt the sky.

The woods are made for the hunters,
The brooks for the fishers of song;
To the hunters who hunt for the gameless game,
The streams and the woods belong.

There are thoughts that roam from the soul of the pine,
And thoughts in the flower-bell curled;
The thoughts that are blown with the scent of fern,
Are as new and as old as the world.

So, away, for the hunt in the fern-scented wood,
Till the going down of the sun;
There is plenty of game still left in the woods
For the hunter who has no gun.

So, away, for the fish, by the moss-bordered brook,
That flows through the velvety sod;
There are plenty of fish still left in the streams
For the angler who has no rod. —Anon.

A Study of Some Achievements of Pupils in the Special Sciences—General Science versus Non-General Science Groups—in the High Schools of Kansas City, Missouri

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INTRODUCTION

In this study attention has been directed to the teaching of general science as a preparation for later science courses. In general we have asked the question "Does achievement in general science predict a similar achievement in the special sciences that are ordinarily taught in the high school?" An attempt was made to find out if general science could be justified in the high school curriculum with special emphasis on the carry-over, if any, from it to the more specialized high school sciences.

According to the current literature on the subject we may summarize the present aims of general science as follows. They are listed in the order of their importance as determined by the number of times they occur in the literature.[1]

1. Better understanding and control of environment.
2. Information about nature and science.
3. Preparation for later science courses.
4. Training in scientific method.
5. Development of power of interpretation.
6. Development of interest in science.
7. Culture.

There has been but little serious effort on the part of anyone to find out if these aims are really being accomplished. Practically all that has been written on the subject is mere opinion. Teachers of the special sciences often offer the criticism that general science causes their pupils to lose interest because the novelty of the subject has been taken away by the previous study. This is in direct contrast to aim number six above. In fact, aims two, three, four, five and six, if attained, should all contribute directly to a greater success in the special sciences that follow. We are all familiar with the objection to general science that it is often made a hodge-

1 Watkins, Ralph K., "The Technique and Value of Project Teaching in General Science." General Science Quarterly, Vol. 7, No. 4, pp. 251-56.

podge of the special sciences. This criticism the writer believes is not true in the Kansas City high schools where this study was made. Andrews[2] offers the criticism that general science fails to accomplish what is claimed for it because it is "shallow and superficial." On the other hand, in spite of the newness of the subject and the generalized nature of its content it has aroused a "volume of popular interest sufficient, not only to warrant its place among secondary school subjects, but also to place it among the required subjects in numbers of secondary schools."[3]

In view of these contrasting opinions, an inquiry into the effect of the teaching of General Science upon some of the well-established specialized sciences in the high school seemed distinctly worth while.

THE STUDY ANALYZED

The idea of carry-over or transfer from General Science to any one special science assumes in the first place, that there are certain identical elements common to both sciences.[4] That there are identical elements common to general science and the special high school sciences has been shown conclusively by several studies that have been made.[5] In the second place, in order to show a transfer of training, it would be necessary to show that those identical elements had been acquired in a general science class previous to the time they were studied in the special science. Not only must we show that the pupil at the close of a course in general science actually has more information of the kind that is included in the special sciences, but, we must show that he has more than he would have had had he not taken the general science course.

But this alone will not solve our problem. We must go farther and show that there is a positive correspondence between success in general science and success in the special sciences. That is, we must find out if achievement in general science tends to be followed by a similar achievement in the special sciences. Furthermore, if we find that intelligence is a factor in achievement in the special sciences we must seek a method of ruling it out or holding it constant.

2 Andrews, W. E., "Correlation in High School Science Courses." School Review, Vol. 27, pp. 1-12.

3 Dvorak, August, "A Study of Achievement and Subject Matter in General Science." General Science Quarterly, Vol. 10, pp. 289-310.

4 Gates, A. I., "Psychology for Students of Education." Macmillan, 1925, ch. 15.

5 Leker, W. R., "The Articulation of General Science with the Special Sciences." General Science Quarterly, Vol. 9, pp. 158-173.

But since many other factors than intelligence and a previous course in general science may contribute to success in the special sciences we need to ask a further question. Do the pupils who have had a course in general science rank higher in scholarship in the special sciences than similar pupils who have not had such a course? In what measurable degree, if any, is the accomplishment of the general science group superior to that of the group who have not preceded their special science course by a course in general science?

Lastly, if we find that higher scholarship is attained in the special sciences by those who have previously had general science, is this higher scholarship attained in all the special sciences without exception? Is there a lack of transfer in some and an apparent transfer in others, or is there an evident transfer in each? In which, if any, of the special sciences is the transfer most pronounced?

To summarize we believe we may be able to find the correct solution to our thesis in the answers to the following questions:

1. Do students who have had general science have any more scientific information than those who have not had it?
2. Does achievement in general science tend to be followed by a similar achievement in the special sciences?
3. In what measure, if any, is success in the special sciences directly attributable to a previous study of general science?
4. Is the transfer from general science to the special sciences as found in answers to questions (2) and (3) consistent?

METHOD

(a) *The Groups Studied.* This study was made in the high schools of Kansas City, Missouri. All data were collected from the Freshman, Sophomore, Junior and Senior classes of the school year 1924-25. All reference to high school classes will mean the classes of this school year unless otherwise stated. It includes students of the second year[6] class in the Central Junior High School, the Sophomore, Junior and Senior classes in the Central Senior High School and a few of the same last three mentioned classes of Northeast High School.

6 The second year class in the junior high schools of Kansas City, Missouri, corresponds to the freshman class of the four-year high school.

It is evident from the summary at the close of the preceding section that data will be required for two entirely distinct groups of students. We shall name them group I and group II. Group one will be taken from the Freshman class of Central Junior High School. It will include first, those Freshmen who completed a whole year of general science during the school year 1924-25. We shall name this sub-group Ia. Second, those freshmen who had not previously taken or did not take general science during the year 1924-25 will be called sub-group Ib. They will be a control group for Ia. These pupils shall be used to answer question 1 in the foregoing.

Group II will be made up of pupils of the sophomore, junior and senior classes who took a special science during the year 1924-25 or had taken a special science before the year 1924-25. The special sciences included are botany, human physiology, zoology, physics and chemistry. Biology is the only other special science taught at Central High School and we have not included it because it is made up of one semester each of botany and zoology. Group II will contain two subgroups of pupils. First, sub-group IIa will be composed of pupils who had preceded the study of the special science by one year of general science. Second, sub-group IIb will be a control group for IIa and will be made up of pupils who did not precede the study of the special science by any other science. It is important to note that a pupil can be eligible to group II only once although he may have studied three or even four different special sciences. He is eligible only when he is taking his first special science. This precludes the possibility of a transfer from one special science to another.

(b) *Collection of Data.* Group I. As has been indicated in the preceding division data for group I were collected from the freshman class of Central Junior high school, 1924-25. There were about 1100 enrolled in classes open to freshmen. The following data were required for each pupil: (1) Student's name; (2) intelligence test score; (3) general science test score, from A; (4) general science test score, from B; (5) item four minus item three. The Ruch-Popinoe general science test was given the 1100 freshmen in the fall and again near the close of school. The intelligence test score was obtained from the office records. It is given every year to the

freshman class sometime during the last semester. It was used as a basis for pairing sub-groups Ia and Ib.

Group II. Data for this group were collected from the office records of Central and Northeast high schools. It was the original intention to confine the study to Central high school but so few cases were obtainable there in Physics and Chemistry that it was thought best to consult the records of Northeast. About the same type of work is given at the two schools and the (horizontal) classification of the pupils is exactly the same, being in charge of the same person at both schools. The following data were collected for each pupil of sub-group IIa: (1) pupil's name; (2) Terman group intelligence test score; (3) date Terman test was taken; (4) General Science grade; (5) special science grade; (6) year and semester special science was taken; (7) all other grades made during the semester the special science was taken; (8) date of entering school. In item seven the grades in the non-solids (subjects that count for half credit only) were underlined so that they would count only half in averaging. Data for sub-group IIb were the same except there was no General Science grade (item 4) to record.

The Terman test scores made during the freshman year are kept on file in the office and were the source of item (2). Data for all other items on the data sheets were found on the permanent individual record cards. Cards were investigated for all pupils entering in September, 1921 or later, even though they had withdrawn from school.

(c) *Pairing.* All pupils attending Central and Northeast are given the Terman Group Test of Mental Ability in the spring of their freshman year. These test scores are later used as a basis of classifying them into A, B, and C sections for class work. Therefore, it seemed entirely appropriate to use these same scores as a basis for pairing.

In the case of group I above, the raw scores were used for pairing without change. A maximum of only four points of the score was allowed in pairing. However, pairing in group II presents a different problem. To illustrate, let us assume a group of seniors of 1924-25 who are eligible to group II according to the conditions stated above and who took botany as their special science. All of them would have taken the Terman test in the spring of 1922. Most of them probably would have taken botany during the sophomore year but a

part of them would have taken it in their junior year, and still others during their senior year. It would be unfair to pair a pupil who had made a score of say, 100, and who had taken botany during his sophomore year with another pupil who had made a score of 100 and had taken botany during his senior year, for the latter pupil would have the advantage of two full years of mental growth not recorded in his intelligence score. Therefore, before any pairing could be done in Group II, all the intelligence test scores had to be made comparable at the time the special science was taken. This was accomplished by means of Table I, page 9, of the manual of directions of Terman's group test. In this table percentile scores are given for each grade from seven to twelve inclusive. In our study the scores made were most nearly like those given for the tenth grade of Terman's table. Therefore, if a pupil took his special science during his sophomore year the test score was taken as a basis for pairing without change. But if he took his special science in his junior year or his senior year, it was necessary to estimate what his score would be at that time, before pairing could be done.

In pairing pupils of group II, a maximum difference of only five points between the Terman scores was allowed in botany, physiology, and zoology, and in most cases, in physics and chemistry. However, because the number of cases was so small in these latter sciences it was thought best to allow a wider difference in a few cases. In no case was this difference more than eleven points which, according to Terman's table of mental ages on page 10 of the manual of directions, is about six months of mental age.

(d) *Procedure.* Of the 1100 freshmen who took the Ruch-Popinoe general science test nearly 500 were disqualified for purposes of this study, owing to various irregularities. When pairing was complete there were 310 in each of the equivalent groups, or a total of 620. These constituted group I and were used to answer question (1) in the analysis. Let D be the difference between the final test and the initial test of the general science pupils, Ia, and d the difference between the final test and the initial test of the control pupils, subgroup Ib. Then the actual gain, if any, in scientific information will be D minus d.

Question 2 in the analysis is best answered from a study

of the following correlations and partial correlations for each special science and for sub-group IIa as a whole:

(1) Correlation between the grades made in general science and the grades made in the special science. (2) Correlation between general science grades and intelligence test scores. (3) Correlation between special science grades and intelligence test scores. (4) By partial correlation hold intelligence constant and find the correlation between general science grades and special science grades.

To answer question 3, Chapter III, four steps will be taken. We shall describe them using botany as the special science, since the procedure was the same for each of the five special sciences studied.

(1) Pair each pupil who preceded his study of botany by a course in general science (sub-group IIa) with a pupil who did not precede his study of botany with a course in general science (sub-group IIb). This will hold intelligence constant. (For distribution of mental scores see table II.)

(2) Using the grades made in botany as a measure of achievement the mean was found for each sub-group. In doing this the following values were assigned to the grades: F = 0, P = 2, M = 4, G = 6, E = 8. If we let Ma equal the mean of all botany grades made by pupils of sub-group IIa, and Mb equal the mean of all botany grades made by pupils of sub-group IIb, then, Ma minus Mb may be thought of as the amount of achievement in botany by which the general science group excelled the control group. But we know that many factors enter into scholarship, other than the factor of intelligence, and that a general superiority is likely to exist in either sub-group IIa or IIb. Let us suppose a general superiority really does exist in sub-group IIa then to find the actual amount of achievement by which IIa exceeds IIb, we must subtract this general superiority from the difference Ma minus Mb.

In step (3) an attempt was made to find any general superiority that might exist in either sub-group in the following way. The average grade, made during the semester botany was taken, was found for each pupil. The mean of these averages was found for each sub-group. Then the difference between these means was taken as the general superiority of the one group over the other. In finding the average grade for each pupil the same numerical values were assigned the

grades as those mentioned in step (2) above in the solid subjects. For the non-solids, or those subjects which were supposed to require no preparation outside of the class period and for which only half credit is allowed, we assigned the following values to the grades: F = 0, P = 1, M =2, G = 3, E = 4. These are just half the values assigned to the grades of the solid subjects.

(4) After correcting the quantity Ma minus Mb for any general superiority that might exist in either group the resulting measure is taken as the actual amount by which achievement in botany is directly attributable to a previous study of general science. In this step the results of all the special sciences are thrown together in order to get the average measure of achievement.

Question (4) of the analysis can now be answered without any further computations, by merely comparing the results in each of the special sciences.

RESULTS

(a) FRESHMAN GROUP. GENERAL SCIENCE INFORMATION TEST.

TABLE I. *Frequency Distribution of Mental Test Scores Showing a Comparison of the General Science Group of Freshmen and the Control Group.*

Terman Group Intel. Test Score	Gen. Sci. Group (Ia)	Control Group (Ib)
181—190	5	5
171—180	7	7
161—170	22	20
151—160	17	19
141—150	20	20
131—140	30	29
121—130	40	44
111—120	37	35
101—110	41	39
91—100	33	35
81— 90	28	26
71— 80	18	18
61— 70	9	9
51— 60	1	2
41— 50	2	2
N	310	310
Q1	96.9	96.9
Mdn.	117.2	117.9
Q3	138.8	138.8
PE diff. (mdn1 — Mdn2) = 2.11		

The fact that the experimental and the control groups are equivalent as measured by the Terman Group Test of Mental Ability is quite evident from table I.

TABLE II. *Results of the General Science Information Test in Terms of the Difference, Final Test minus Initial Test, for Each Group—Ia and Ib.*

Difference	Gen. Sci. Group	Control Group
29—30.9	2	..
27—28.9	3	..
25—26.9	5	..
23—24.9	5	..
21—22.9	6	..
19—20.9	17	..
17—18.9	27	..
15—16.9	33	..
13—14.9	44	3
11—12.9	43	1
9—10.9	39	2
7— 8.9	36	21
5— 6.9	28	34
3— 4.9	11	51
1— 2.9	8	50
—1— 0.9	2	55
—3— —1.1	0	50
—5— —3.1	1	27
—7— —5.1	..	12
—9— —7.1	..	4
N	310	310
Q1	8.5	—1.6
Mdn	12.4	1.3
Q3	16.2	4.4

PE diff. (mdn1 — mdn2) = .346

The difference between the medians necessary to account for fluctuations due to sampling is $4 \times .346$ or 1.384. The difference obtained here is 11.1 or eight times as large. Hence, the data of table II show that the general science group gained more scientific information, as measured by the Ruch-Popinoe test, than did the control group.

(b) CORRELATIONS. GROUPS FROM THE SPECIAL SCIENCES.

TABLE III. *A Summary of Correlations Showing the Correspondence between Success in General Science and Success in the Special Sciences.*

	Bot'y Gr. N=100		Chem. Gr. N=25		Phys. Gr. N=50	
	2 Bot.	3 Intel.	2 Chem.	3 Intel.	2 Phys.	3 Intel.
1. Gen. Sci. ..	.36±.06	.31±.06	.59±.09	.43±.11	.63±.06	.44±.08
3. Intelligence	.40±.06		.65±.08		.19±.09	
	$r_{12\cdot3}$ = .27		$r_{12\cdot3}$ = .66		$r_{12\cdot3}$ = .70	

	Physl. Gr. N=100		Zool. Gr. N=100		Total Spec. Sc. N=375	
	2 Physl.	3 Intel.	2 Zool.	3 Intel.	2 Sp. Sc.	3 Intel.
1. Gen. Sci. ..	.39±.06	.40=.06	.35±.06	.46±.05	.40±.03	.46±.03
3. Intelligence	.23±.06		.46±.05		.36±.03	
	$r_{12\cdot3}$ = .37		$r_{12\cdot3}$ = .18		$r_{12\cdot3}$ = .29	

Interpretation of the table for the subject, Botany, is as follows: For 100 pupils who preceded their botany by general science the correlation between their general science grades and their botany grades is .36 ± .06, the correlation between their general science grades and their intelligence scores is .31 ± .06 and the correlation between their botany grades and their intelligence scores is .40 ± .06. The correlation between general science and botany when the factor of intelligence has been held constant by partial correlation is .27.

Probably the most significant fact about these correlations, so far as this study is concerned, is that the correlations between general science and the special sciences are consistently positive.

(c) STUDY OF ACHIEVEMENT IN THE SPECIAL SCIENCES.

TABLE IV. *Showing the Intelligence Rating for Each of the Special Sciences.*

	Botany		Chem'sty		Physics		Physiol.		Zoology		Total	
	G. S.	C.	G. S.	C.	G. S.	C.	G. S.	C.	G. S.	C.	G. S.	C.
N	100	100	25	25	50	50	100	100	100	100	375	375
Q3	138.3	137.7	185.3	189.2	170.6	172.7	142.7	143.3	146.0	145.6	152.3	151.0
Mdn	118.8	117.6	172.5	171.3	152.7	156.7	124.4	124.3	126.9	125.7	128.4	128.7
Q1	111.7	111.0	154.2	151.3	129.0	133.8	110.0	105.4	110.0	110.6	110.3	109.0

The columns headed "G. S." refer to pupils who studied one year of general science before taking the special science, referred to in the foregoing as sub-group IIa. The columns headed "C" refer to the control groups who did not study general science before taking the special science, sub-group IIb. Q_1, Median, and Q_3 are given in terms of intelligence test scores. Table IV shows that the two sub-groups are equivalent as measured by the Terman Group Test of Mental Ability.

TABLE V. *Comparison of Achievement in the Special Sciences as Attained by the General Science Group (G. S.) and the Control Group (C).*

	Botany		Chem'sty		Physics		Physiol.		Zoology		Total	
	G. S.	C.	G. S.	C.	G. S.	C.	G. S.	C.	G. S.	C.	G. S.	C.
I	4.34	4.26	5.28	4.56	4.16	4.44	4.50	4.00	4.18	4.12	4.38	4.20
II	4.03	4.27	4.91	5.33	3.93	4.58	4.02	4.09	3.97	4.15	4.06	4.30
III		.24		.42		.65		.07		.18		.24
IV	4.34	4.02	5.28	4.14	4.16	3.79	4.50	3.93	4.18	3.94	4.38	3.96
V	.32		1.14		.37		.57		.24		.42	
N	100	100	25	25	50	50	100	100	100	100	375	375

I is the average grade in the special science.

II is the average grade in all subjects during the semester the special science was taken.

III is the superiority in scholarship of one group over the other, i. e., the difference between the column "G. S." and the column "C" in row II.

IV is the average grade in the special science after correction for superiority. (See step 3, page 8.) For example, the control group in botany was superior in scholarship by .24 point. This amount must be subtracted from 4.26, the average botany grade of the control group, in order to make it comparable with the average botany grade (4.34) of the general science group.

V is the actual superior achievement in the special science attributable to a previous study of general science. (Difference between column "G. S." and column "C" of row IV.)

N is the number of pupils involved.

In averaging grades F = 0 P = 2 M = 4 G = 6 E = 8.

There seems to be a significant difference in each special science in favor of the general science group. In this connection it should be remembered that the factors contributing to achievement in any special science, that are attributable to a previous study of general science, would be small compared to the total number of factors contributing to achievement in that special science.

CONCLUSIONS

The analysis of the problem called for the answers to four special questions. We are now ready to answer these on the basis of the data presented. Under the conditions out of

which our data grew and in the field of our study we believe the correct answers to be.

1. Students who have had a course in general science have more scientific information than do similar students who have not had such a course.

2. There is a positive correspondence between achievement in general science and in the special sciences. While the correlation is not high it is consistent even when the factor, intelligence, had been held constant. These positive correlations mean simply that success in general science tends to be followed by a like success in the special sciences. It may be true, but it does not necessarily mean, that the success in the subsequent science is caused by success in general science. However, in this study, the first, third and fourth conclusions would imply this.

3. According to table V there is a measurable success in the special sciences that is apparently due to a previous study of general science.

4. The transfer or carry-over from general science to the special sciences is consistent in that it is positive for each science studied. It is not the same for each science. We would not expect it to be the same since the identical elements in each case would not be the same. The significant point for this study is the fact that there is a superior achievement in each one of the special sciences that is apparently attributable to a previous study of general science.

In general then we may say that, in the field studied, general science does seem to prepare students for a study of the special sciences. There is apparently a transfer of training from general science to the special sciences studied.

SUMMARY

In this study we have attempted to find out if general science served as a preparation for a study of the special sciences taught in the high school. The special sciences studied were Botany, Chemistry, Physics, Human Physiology, and Zoology and the place of the study was in the high schools of Kansas City, Missouri.

Briefly our procedure has been as follows:

1. By means of a General Science information test, to find out if pupils who study general science get any more

scientific information during the school year than do similar pupils of equivalent intelligence.

2. To secure the correlation between performance in general science and in each special science.

3. To secure the correlation between general science and the intelligence score.

4. To secure the correlation between intelligence score and performance in each special science.

5. To secure the correlation between general science and each special science when the factor of intelligence had been rendered constant by partial correlation.

6. To render the factor of intelligence constant by the equivalent groups method, and, having done this, to discover any superiority that might exist in the general science group.

7. To render the factor of intelligence constant, as in 6, and to determine whether or not a general superiority (as against a specific performance in the special sciences) persists in favor of either group.

8. In case a general superiority was found, to take it into consideration in the final comparison in achievement of the equivalent groups.

Our general conclusion is that there seems to be a carry-over from general science to the special sciences and that, therefore, general science does apparently serve as a preparation for a study of the special sciences.

Guilty Gullies and Erosions

Approximately 17,500,000 acres of land in the United States, formerly cultivated, have been destroyed by gullying. or so severely washed that farmers cannot afford to attempt cultivation or reclamation. This is enough land to support a nation, says the United States Department of Agriculture, and it exceeds the total area of tillable land in Japan.

Recent estimates of specialists of the United States Department of Agriculture indicate that a total of 126,000,000 pounds of plant food is washed out of the fields of the United States every year. This is 21 times as much as the amount of plant food used by crops.

Curriculum Construction in Chemistry

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The process of curriculum building in a traditional subject-matter field presents unusual difficulties. Theoretically, a curriculum builder should make an analysis of all of the activities of life, and from this select those activities the performance of which is to be conditioned by a course in chemistry. These activities should constitute the ultimate objectives of the course. The abilities necessary to perform these activities should constitute the immediate objectives. The next step is the provision of learning activity which will enable the students to acquire the abilities designated as immediate objectives. Thus the instructor, by requesting the performance of a learning exercise, stimulates the students to learning activity which will enable them to acquire abilities useful in the conduct of certain activities in later life. The difficulty arises, in the construction of a chemistry curriculum, from the complex inter-relationship existing between learning exercises on the one hand, and ultimate objectives on the other.

If one were building a curriculum in auto mechanics the process would be relatively simple. An analysis of the activities of efficient auto mechanics would yield items quite distinct from each other. The abilities necessary to perform these activities would be quite apparent; and the learning exercises would simply be requests to perform the activities themselves in a school environment. In the construction of a chemistry curriculum the process becomes much more complicated. It is the purpose of the author to outline the procedure for building a chemistry curriculum, and to indicate the nature of the difficulties which are likely to be encountered.[1]

The determination of the ultimate objectives. The ultimate objectives of the chemistry curriculum have been defined as those activities of life, the performance of which is to be conditioned by subjecting the students to the course in chemistry.

1 The author is indebted to Professor Walter Scott Monroe for his concept of the general procedures of curriculum construction. This concept recognizes the following phases in the process of building a curriculum: (1) ultimate objectives, (2) immediate objectives, (3) learning activity, (4) learning exercises and materials of instruction, and (5) organization into courses of study.

Two methods of determining these ultimate objectives may be considered. The curriculum builder might make a survey of the various vocations in an effort to secure information pertaining to activities for which chemical knowledge or skill is useful. To this might be added analyses of books, periodicals, and newspapers for frequency of occurence of chemical terms. Finally, an analysis might be made of home activities. If all this were done comprehensively the curriculum builder might arrive at an adequate list of ultimate objectives. However, no matter how thoroughly this might be done, such a formulation of objectives would still be open to serious criticism. The analysis would yield information pertaining to the activities of contemporary life, and would give no basis for claims relative to their desirability for perpetuation. If the curriculum builder selected certain activities as being desirable, he would depart from being "scientific,"[2] and it is probable that another would arrive at quite different results. Finally, the determination of the activities of present day life, yields no certain information relative to what will be done in the future.

The second method of determining ultimate objectives is that by which several competent individuals by the use of critical judgment arrive at a formulation of activities which they consider desirable, and worthy of perpetuation.[3] Such men, if authorities in the field of chemistry, should be able to state on the basis of their own judgments the activities of life which are at the present time being conditioned by study of chemistry, as well the activities which are likely to be conditioned in the future. Such men, if cognizant of present progress in chemistry, should be able to predict what knowledge might prove useful to the average layman some years from now. For example, recent advances in the pure science will ultimately result in applications in industry, which will in turn make necessary certain new vocational activities. Again, it has been quite evident in the past that scientific knowledge tends to become popularized in the course of a few years. The plea is made that this

2 "Scientific" in this sense means "objective." It has been used thus by activity-analysts and their critics to denote a technique from which the personal element has been eliminated.

3 For a discussion of this method of determining ultimate objectives, see Rugg, H. O., "Problems of Contemporary Life as the Basis for Curriculum Making in the Social Studies," Twenty-Second Yearbook of the National Society for the Study of Education, Part II, Bloomington, Public School Publishing Company, 1923, pp. 260-273; and, Hockett, J. A., "A Determination of the Major Social Problems of American Life," Teachers College, Columbia University Contributions to Education, No. 281, New York, Bureau of Publications, Columbia University, 1927, 101 p.

spread be anticipated, and perhaps insured. Surely the trends of modern civilization are not so obscure but what they may be interpreted in terms of the next few years. As time goes on the ultimate objectives could be modified as the need arises.

How to state ultimate objectives. In listing the activities designated as the ultimate objectives it is appropriate to use the present participle of the verb denoting the activity. Thus the activity in which an individual reads popular magazine articles pertaining to the structure of the atom might be stated as follows:

> Reading popular magazine articles pertaining to atomic structure.

It will be found practical to state major activities in somewhat general terms, and to limit the list to possibly no more than twenty. Then each of the general items could be used as headings for related more specific activities. Such a classification is much more easily comprehended than a long, unordered list.

The determination and classification of immediate objectives. The immediate objectives have been defined as the abilities necessary for the performance of the activities labeled ultimate objectives. In the construction of a chemistry curriculum the difficulty arises that each of these activities demands not one, but several abilities. These same abilities may be useful in the performance of other activities. Thus reading an article in which chemical phenomena are discussed will require the ability to give meaning to the terms used, the ability to apply such knowledge in this new situation, and an attitude of interest in such reading. While this demand for the recognition of a variety of abilities for each activity makes the process of curriculum construction much more difficult, the fact that many of the abilities are useful for other activities tends to simplify the procedure. It is only necessary that some scheme for the classification of immediate objectives be employed, and that the curriculum builder eliminate repetition of abilities. One statement of an ability is sufficient if its relationship to several of the activities is shown by symbols representing these activities. Thus the statement of an immediate objective (ability) should be followed by several numerals which stand for the ultimate objectives (activities). Thus one can see the relationships between abilities and activities by the interpretation of

these symbols. Several numerals after an ability indicate that it contributes to several activities. The occurence of the same numeral after several of the abilities indicates that the activity symbolized requires the engendering of several abilities. The following classification of immediate objectives will prove very useful:

IMMEDIATE OBJECTIVES.

I. *Fixed controls of conduct.* This includes the abilities needed in responding to familiar situations. Under this heading should be placed such motor skills as the ability to fire-polish glass tubing, and such fixed associations as the abilities to give the symbols of the common elements.

II. *Adaptive controls of conduct.* This includes the abilities required in applying chemical knowledge in new situations. The abilities needed in forming abstract and general meanings should be placed under this heading. The term skill in reflective thinking is applied to this classification of abilities.

III. *General patterns of conduct.* Under this heading should be listed the attitudes, ideals, and interests which are to be among the outcomes of the course in chemistry. Such general patterns of conduct function in a variety of situations, and contribute in this way to the performance of the activities designated as ultimate objectives.[4]

Learning activity and its relation to objectives. By learning activity is meant the doing of appropriate tasks, *on the part of the learner,* through which he acquires the abilities designated as immediate objectives. The engenderment of a variety of abilities demands that the pupil engage in a variety of learning activities. In acquiring the ability to define a chemical term the pupil must be busied with associating the term with its meaning until the association becomes fixed in his mind. In acquiring the ability to use chemical knowledge in meeting new situations, it is essential that the pupil be exercised in applying the knowledge to a variety of situations. In acquiring attitudes, ideals, and interests no specific learning activities may be asked for. The instructors must make use of opportunities as they arise to engender these abilities as by-products of other learning. Thus the interest which the instructor shows in his subject may inspire his pupils to a like interest. In order to prevent the emphasis on the attainment of some objectives at the expense of others, it is essential that the instructor provide a "balanced ration." In listing the learning exercises, or requests

4 For a more detailed discussion of these rubrics, see Monroe, Walter S., "Directing Learning in the High School," Garden City, New York, Doubleday, Page and Company, 1927, pp. 30-31; and, Engelhart, Max D., "A Psychological Basis for Objectives," Journal of Chemical Education, 4: 364-369, March, 1927.

to perform learning activity, it will be valuable to insure some under each of the following types:

1. Direct or perceptual experiencing.
2. Vicarious experiencing.
3. Generalizing experience.
4. Comprehending the products of thought.
5. Using one's knowledge in manufacturing a response to a new situation.
6. Tracing the thinking of another person.
7. Expressing one's ideas.
8. Prolonging, repeating, and intensifying one's experience.
9. Feeling or emotional activity.[5]

Learning exercises and materials of instruction. Learning exercises have been defined as the requests made by the teacher in stimulating and directing the learning activity of the pupils. It has been indicated that these learning exercises should be so formulated as to demand a variety of learning activities. In listing learning exercises it is desirable to list them under the ultimate objectives to which they are related. It is helpful to follow each learning exercises with symbols representing the abilities (immediate objectives) whose engenderment is to be aided by the performance of the learning exercise. The statement of the learning exercise should also include specification of the materials of instruction, or portions of the textbook, laboratory apparatus, visual aids, and so on. Each learning exercise should be more than a mere assignment of pages in the text. Learning exercises should include questions, directions, and other devices for stimulating and directing learning ing activity.

The curriculum as a whole. The process of curriculum building has been traced from the first stage, determination of ultimate objectives, down to the formulation of learning exercises. In thinking of the curriculum as a whole it is sometimes helpful to start at the learning exercise and note the relationships to learning activity, immediate objectives, and ultimate objectives. To recapitulate, each learning exercise should stimulate the pupil to learning activity so that he acquires an ability, or abilities, which will be useful in performing an activity, or activities in his later life. The more definitely this relationship is indicated is the completed curriculum, the greater the assurance that the ultimate objectives will be attained. The chief value to be derived from such a curriculum lies in the fact that it provides the instructor with a chart for chemistry instruction.

5 This classification of learning activities is given with explanation in Monroe, Walter S., "Directing Learning in the High School," Garden City, New York, Doubleday, Page and Company, 1927, pp. 33-37.

An Inventory of Physics and Related Science in Agriculture

(A Study of Farm Shop and Agricultural Engineering Activities on Kansas Farms.)

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The object of the study was to determine the actual farm shop and agricultural engineering activities practices on Kansas farms, and to ascertain the tools and equipment the farmer had with which to perform these activities.

Six communities were surveyed, chosen to represent the different sections of Kansas. The communities selected offered vocational agriculture as part of the high school porgram and no community was chosen where the work had not been offered for at least three years previous to the study. The communities studied were representative of sections of the state in which they were located. All surveys were made in cooperation with the public high school. A conference of the superintendent, vocational agriculture instructor, local banker, and members of the school board selected the farmers of the school district to be included in the survey. A representative group was chosen by keeping in mind the following points: distance from town, size of farm, type of farm, age of farmer, financial status of farmer, farm owners, and tenant farmers. Through the local press the people were acquainted with the purpose of the survey and just as soon as the committee designated the farms to be surveyed each operator was written a personal letter explaining the purpose and plan and informing him of an impending visit on the part of the writer. 100% cooperation was obtained. The six communities surveyed were:

Atchison Community High H. S., Effingham; northeast.
Labette County H. S., Altamont; southeast.
Lincoln H. S, Lincoln; north central.
Harper-Argonia Community, through the high schools in Harper and Argonia; south central.
McDonald Rural High School, McDonald; north west.
Spearville High School; southwest.

Sixty farms were studied in each of the communities in the northeast, southeast, north central, and south central regions. Forty farms were surveyed in each of the northwest and southwest regions.

The questionnaire blank requesting enterprise and job activities together with tools and equipment information was designated in cooperation with the farm shop and the agricultural engineering departments of the Kansas state agricultural college.

The writer visited each of the above mentioned high schools and with the vocational agriculture teacher or the superintendent visited each of the farms included in the survey, and personally checked the questionnaire with the farm operator. This entailed considerable time but assured uniformity and accuracy.

The following represents the averages listed under the major headings in accordance with frequency of occurrence of jobs and tools:

AVERAGES FOR STATE IN ORDER OF FREQUENCY OF OCCURRENCE

I. FARM CARPENTRY

1. Tool Sharpening:
   - Axes 93
   - Wood chisels 86
   - Scythes 79
   - Plane bits 64
   - Drill bits 55
   - Saws 54
   - Auger bits 48

2. General repairs:
   Fitted handles in:
   - Hammers 98
   - Shovels 89
   - Hoes 87
   - Axes 80

3. Small farm appliances:
   - Double trees 92
   - Saw horses 74
   - Ladders 73
   - Hog crates 64
   - Chicken feeders 50
   - Trap nests 5

4. Large farm appliances:
   - Hay rack 84
   - Feed bunk 63
   - Header barge 51
   - Wagon box 50
   - Truck body 11

5. Farm building interior construction:
   - Mangers 87
   - Stalls 86
   - Grain bins 69
   - Stanchions 64
   - Feed chutes 4

6. Building construction:
   - A. Has built:
     - Poultry house 68
     - Hog house 62
     - Granary 48
     - Garage 39
     - Corn crib 38
   - B. Helped build:
     - Garage 23
     - Granary 20
     - Poultry house 18
     - Corn crib 12
     - Hog house 11
   - C. Has built:
     - Dairy or stock barn... 22
     - Hay barn 20
     - Silo 14
     - Dwelling house 14
   - D. Helped build:
     - Dairy or stock barn... 41
     - Dwelling house 37
     - Hay barn 33
     - Silo 30

I-a. TOOLS AND EQUIPMENT

- Hand saw 99
- Wood chisels 98
- Rachet brace 97
- Steel square 96
- Screw driver 96
- Grindstone 80
- Hand axe 76
- Rip saw 75
- Rachet brace 74
- Hatchet 72

Draw knife	70	Gimlet bits	42
Saw files	67	Nail set	41
Wrecking bar	65	Saw set	41
Carpenters level	65	Emery wheel	33
Work bench with vise	64	Bevel square	32
Hand axe	59	Mallet	30
Oil stone	55	Marking gauge	30
Jack plane	54	Plumb bob	27
Folding rule	51	Expansive bit	26
Keyhole saw	50	Block plane	25
Have farm shop	49	Countersink bit	23
Chalk line	49	Hand screws	19
Tri squares	46	Back saw	15
Smooth plane	45	Bar clamps	8

II. BLACKSMITHING

Drill holes in metal	58	Weld	14
Cut threads in bolts	42	Shoe horses	11
Cold bend rods	37	Weld chains	9
Make gate hooks	22	Make screwdrivers	9
Make punches	20	Set wagon tires	8
Sharpen plowshares	20	Point plowshares	7
Make single tree hooks	18	Point harrow teeth	7
Make clevises	18	Point cultivator teeth	6
Make cold chisels	16	Sharpen discs by heating	3

II-a. TOOLS AND EQUIPMENT

Sledge	49	Flat tongs	29
Vise	48	Hardie	20
Set drill bits	48	Bolt tongs	16
Set hammer	46	Cold cutter	13
Blacksmith hammer	35	Hot cutter	11
Stocks and dies	34	Handled square punch	8
Anvil	33	Set hammer	6
Drill press	32	Flatter	3
Handled punches, round	20	Swedges	3
Forge	29	Fuller	1

III. SOLDERING

Buckets	40	Radiators	17
Milk cans	38		

III-a. TOOLS

Soldering iron	42	Flux	21
Solder	41	Gasoline torch	13
Tin snips	33		

IV. HARNESS REPAIRING

Rivet	95	Clean and oil	70
Replace iron parts	84	Sew	33

IV-a. TOOLS

Harness punch	79	Lockstitch awl	20
Awl	39	Sewing horse	10
Riveting machine	57	Pricking wheel	1
Needles	28		

V. PLUMBING, WATER SUPPLY AND SANITATION

Replace pump leather	92	Laid sewer pipe drain	19
Installed pump	62	Walled well	18
Dug well	63	Installed bath tub	11
Installed pipe	53	Installed water heater	5
Erected windmill	48	Septic tank	5
Cut, threaded and fit pipe	46	Calked cast-iron soil pipe	4
Installed pump jack	46	Installed toilets	3
Built water tank	37	Installed pipeless furnace	3
Installed kitchen sink	33	Installed hot air furnace	3
Repaired down spouts	30	Installed hot water furnace	1
Walled cistern	26	Installed steam furnace	1

V-a. TOOLS

Pipe wrench	73	Pipe cutter	10
Pipe vise	18	Pipe dies	9

VI. MOTORS

Have automobile	93	Have gasoline engine	45
Cleaned spark plugs	82	Cleaned battery terminals	44
Removed carbon	81	Overhauled transmission	41
Adjusted brakes	78	Timed gas engine	40
Tightened clutches	71	Test storage batteries	36
Replaced gaskets	70	Overhauled automobile	33
Ground valves	68	Overhauled gas engine	30
Adjusted breaker points	64	Have tractor	29
Replaced piston	61	Babbitted bearings	26
Taken up connecting rod	60	Overhauled tractor	20
Repaired electrical wiring	54	Timed tractor	21
Taken up main bearings	52	Have electric motor	8
Replaced bushings	49	Overhauled light plant	3

VI-a. TOOLS

Monkey wrench	98	Set socket wrenches	48
Screwdriver	97	Valve grinder	35
Pliers	96	Other wrenches	35
Files	89	Speed wrenches	28
Set end wrenches	65	Set reamers	13
Crescent wrench	61	Valve lifter	35
Hack saw	58		

VII. FARM MACHINERY

Replaced Pitman rod	94	Operated feed grinder	64
Installed ledger plates	93	Adjusted mower cutter bar	60
Replaced broken tongues	92	Overhauled binder	55
Installed guards	90	Replaced Pitman rod—corn binder	54
Installed sickle section	90	Operated wood saw	51
Adjusted twine tension	90	Operated corn sheller	48
Adjusted binder knotter	89	Squared canvas rollers	47
Replaced broken castings	86	Overhauled header	37
Adjusted knife	85	Filed discs	31
Relaced Pitman rod-binder	84	Operated threshing machine	31
Replaced brace rods	83	Operated ensilage cutter	26
Adjusted needle	83	Operated hay press	25
Repaired drive chains	82	Calibrated grain drill	22
Removed gear keyed to shaft	81	Calibrated corn planter	22
Replaced worn bearings	77	Constructed multiple hitches	17
Constructed multiple hitches—horses	73	Overhauled combine	3

VIII. CONCRETE WORK

Built forms	73	Built walks	62
Built foundations	67	Built troughs	34
Built floors	66		

VIII-a. TOOLS

Trowel	70	Mortar hoe	17
Mortar box	46	Concrete mixer, hand	14
Float	29	Concrete mixer, power	5

IX. MISCELLANEOUS FARM JOBS

Built wire fence	95	Repaired flues	39
Hang gates	84	Installed hay rack	38
Paint exterior building	82	Short spliced rope	36
Laced belts—rawhide	68	Repaired plastering	46
Installed roller door track	62	Long spliced rope	34
Paint interior finish	55	Laced belts, wire	15
Paint floors	51	Installed line shaft	13
Paint farm machinery	50	Spliced belts, glued	8
Laced belts—metal	48	Built concrete posts	6
Repaired plastering	48	Installed litter carrier track	5
Made rope halters	44	Installed farm grain elevator	5

X. MISCELLANEOUS

A. Home conveniences:		Pump water, wind	47
Have kitchen sink	43	Have feed grinder	46
Have hand washing machine	43	Have hand sprayer	43
Have power washing machine	31	Have manure spreader	42
Have bath room	24	Have brooder	30
Running water in house, pressure	11	Have silo[1]	22
Have inside toilet	10	Pump water, wind and engine	17
Running water in house, gravity	8	Have threshing machine[2]	14
Individual electric lighting system	8	Have silage cutter	13
Power line system	6	Pressure water systems	8
Have septic tank	5	Gravity water systems	7
Have cesspool	5	Running water, barn	5
Acetyline lighting system	4	Have septic tank	4
B. Have cream separator	88	Pump water, engine	4
Apply barnyard manure	71	Pump water, electric	3
Kill and cure meat	65	Have milk tester	2
Have incubator	57	Have power sprayer	2
		Have milking machine	2
		Average number acres manured annually	12.05

1 Includes pit silos.
2 Includes combines.

The material gathered was compiled on the basis of per cent of farmers in a given community doing certain jobs, or having certain tools. For example, the number of farmers in a community who completely overhaul tractors is not based on the per cent of farmers owning tractors, but rather sets forth the farmers in the community who do that work. Twenty-nine per cent of the 320 farmers included in the survey have tractors, and twenty per cent overhaul. When we determine the per cent of farmers owning tractors we find it equals approximately seventy per cent.

The study shows the number of jobs done by the farmers, but does not furnish information relative to proficiency.

It lists the number of farm shops found, but does not set forth the adequacy of same.

It lists the tools found on the farms, but does not give information as to the quality or condition in which they are kept.

It shows the actual farm shop level, but does not furnish information relative to potential possibilities.

While the actual level is shown, there is no data to point out the number of jobs left undone because of lack of proficiency in skills required, thereby tending to keep the level to a low point.

Course of Study in Biology for Senior High School and Junior College[1]

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Introduction

The recent development of the junior college in the United States may be best interpreted as the upward extension of the high school. One of its main purposes is to provide a new completion point in education. Accordingly, the process of combining the last two years of high school and the two years of junior college has already begun and is likely to continue until a new unit in our school system will be widely adopted. In fact a number of schools have already been reorganized in that way. An example of this type of school may be found in Hillsboro, Texas, Pasadena, California, and in many of the state junior colleges. If such a new unit is to be made most effective as an educational instrument, the curricula ought to be reconstructed to fit the needs of the system so developed.

The development of the junior college is no longer in the experimental stage. In spite of that fact, much remains to be done in the way of stabilizing the work and establishing the proper relations between this unit and the high school on the one hand, and between it and the senior college on the other.

It has been the aim of this study to project a curriculum in the biological sciences that would provide for the needs of all the various groups of students who attend this new unit. An attempt has been made to ascertain what courses in biology are now being taught in the high schools and junior colleges of this country. Courses of study and requirements for graduation as taken from catalogs of 201 junior colleges and from high school and state bulletins and courses of study representing, as nearly as possible, all sections of the United States have been thoroughly examined. From these sources typical courses have been outlined as they are now given and deductions have been made which have resulted in the scheme proposed in the last part of this treatise.

Very little work has been done toward working out courses of study for biology in the new type of school as mentioned above. Certainly it is true that there is a lack of correlation

1 Summary of Master's Thesis, University of Texas.

between the courses in high school and those in the first years of college. This lack of correlation is especially noticeable in the biological sciences. The reason for its existence seems to be in the first place, that the teachers who teach in the high schools and those who teach in the colleges fail to realize the state of affairs. They do not realize that much of the work done in freshman college is very much of the same type of work as that done in high school. Then too, the teachers of high school and those of the colleges probably never get together when curricula are to be constructed. But when the senior high schools and the junior colleges are brought under the same administration, the problem of reconstruction of curricula will bring out the prodigality of the present system and the much-needed changes can be more readily made. The teacher of freshman college biology in the smaller junior college frequently will be the same person that teaches it in high school.

HISTORY OF BIOLOGY IN THE SCHOOLS

The study of biology in the schools as a distinct science is comparatively new but has attained a vast significance during the past century. The recent developments of this science have revolutionized the study of medicine and other scientific arts. Many changes have accordingly been made in curricula in order to accommodate the various groups of people preparing for medicine, pharmacy, nursing, agriculture and even for general education.

Zoology, with special reference to the study of medicine, has been taught for several centuries, while the other branches of biological science have made their appearance only within comparatively recent times. Aristotle wrote and lectured on the history of animals. His work was accurate and based on actual observations.

The next important step in the development of zoology was the work of Vesalius. He dared to break away from so-called authority and dissected a human body and wrote a description of his findings. Then the science grew by leaps and bounds as a result of discoveries made by such men as Harvey, Dujardin, Darwin, Pasteur and many others.

Botany, up till the end of the 18th century, was very limited in its scope. Even as late as the middle of the 19th century

most of the botany consisted mainly of classification. When taught at all, it was usually thrown in with zoology as a side issue. A few American universities had organized separate departments by 1880. From then on, the science has gradually grown until practically every college and university of any size has separate departments for botany and zoology.

The high schools were slow about beginning the study of the biological sciences. In fact practically nothing was done before 1870. But between 1870 and 1890 the laboratory method was introduced. That proved to be an incentive for further study. Public free schools were slow in taking up the study of the biological sciences because, equipment was expensive, administrators were not interested, and the universities were slow to accept the sciences for entrance credits.

As the courses in biology are taught in the high schools and colleges at the present time, there is very little articulation between the courses in high school and those in the college. It is found that in the great majority of cases a course in general biology is offered in the second year high school with no more biology offered till the freshman year in college. The student who has had biology in the high school meets the other one who has had none, in college freshman zoology, botany, physiology or general biology. In order to stay within the range of the student who has had neither of the sciences in high school the college course has to be simplified to such an extent that a great deal of the course is repetition for the student who has had high school biology. Dean Angell of the University of Chicago says, "One can only feel that the educational system which permits or encourages such duplication lacks coordination, that its earlier and later stages are out of touch with one another, and that we have in such maladjustment a form of wastage which is unfair both to the student and to the teacher. Something is surely wrong when college students who have never pursued a given subject can carry it on in college upon entirely equal terms with other students who have made a nominal beginning upon it in school." This lack of articulation needs to be remedied and in the course of time will be.

BIOLOGY AS TAUGHT IN THE AMERICAN HIGH SCHOOL

For the last fifteen to twenty-five years most colleges have been accepting for entrance one or more units of credit for

biological science from the high schools. The most common course is a general biology given, as a rule, in the second year of the high school course. If pure zoology or botany are given they usually are placed in the third or fourth year. The smaller schools limit their courses to the general biology which meets the needs of a general purpose course. Since so many students drop out of school before graduation it is believed that the second year of high school is the logical place for the biology to be taught because it is of greater probable value in life than physics and chemistry. The course in general biology has been neglected in Illinois where botany and zoology are emphasized but in seventeen other states examined we found the general course most prevalent. Out of 251 schools reported to the Commissioner of Education of Massachusetts in 1918, 60.2% of them offered the general biology. Of the 491 high schools reported in Texas in 1926, 47% offered general biology while only 5.5% offered botany and 2.4 zoology. Many other cases might be cited to show the prevalence of the general course of biology except in the larger city schools where greater range of electives is made possible by the large enrollments.

BIOLOGY AS TAUGHT IN THE JUNIOR COLLEGES AND FIRST TWO YEARS OF STANDARD COLLEGES.

The catalogs of 201 junior colleges and of 10 four-year colleges and universities were examined to secure what courses in biology are now being taught in the first two years of college. In making this analysis of the college curricula the schools have been divided into three groups,—(1) small colleges with from one to eight teachers, (2) medium colleges with from nine to twenty teachers, and (3) large schools with more than twenty teachers. The reason for this division being made is that the small school cannot be expected to have as complete and enriched curriculum as the large one. From Table I it is evident that the most common of the biological sciences offered are botany and zoology, 60.7% of all the 201 colleges offering either one or the other, or both. Zoology leads — it being offered in 107 colleges, botany second with 102 schools offering it, general biology third in 58 schools, and physiology fourth with 37 colleges offering it.

TABLE I. *Biology Offered in 201 Junior Colleges.*

Science Offered	*Number of Colleges Offering*	*Percentage of Total*
Botany and Zoology	87	43.5%
Botany alone	15	7.4%
Total Botany	102	50.7%
Zoology alone	20	9.9%
Total Zoology	107	53.2%
Botany or Zoology or both	122	60.7%
Physiology	37	18%
General Biology	58	28.8%
Bacteriology	27	13.4%
Some form of Biology	157	78.1%

An attempt has been made in this study to find how many colleges have arranged their courses in such a way that the various groups of students are cared for in their pre-professional work. As will be seen from Table II, only a small percentage of the colleges have cared for this particular feature, — preparation for the professions, — and but few require any biological science for graduation, although 24.4% offer a pre-medic course.

TABLE II. *Various Requirements in Biology (from 201 Junior College Catalogs).*

Kind of Course	*No. of Colleges Requiring Biology*	*Percentage of Total*
Pre-medic	49	24.4%
Pre-nursing	11	5.5%
Pre-agriculture	18	9%
Pre-pharmacy	2	1%
Pre-dentistry	14	6.9%
Pre-teaching	21	10.4%
Total number of colleges requiring Biology for graduation	30	
Percentage of total requiring Biology for graduation		14.4%

Of the 201 junior colleges studied, 120 were church schools and 17 were private. The others were public. Forty of the church schools offer no biology at all, 20 of which have less than nine teachers, 16 are medium sized and 4 belong to the large schools having more than twenty teachers. It is rather peculiar that these larger church schools do not offer any biology at all. They should at least offer one course of general biology as a general purpose course.

On the other hand, it will be seen from Table III (see next page) that most of the public colleges offer some biology and all of the private schools offer it. There are two small and

two medium-sized public junior colleges that offer no form of biology. None of the large group failed to include some course in biology in its curriculum. The small public junior college usually offers at least one course of general biology. The medium-sized college ordinarily offers enough biology that the pre-medic student will get a fairly good course while the large college, in most instances, offers enough biology that the pre-medic, pre-nursing, pre-dental, and many other professional preparations may be made without loss of time. In fact some of the large public junior colleges offer almost as broad selection as freshmen and sophomores can find anywhere. A good example of this broad selection may be found in Crane Junior College, Chicago. In this school regular courses have been outlined for the pre-medic, pre-nursing, pre-dental as well as majors in zoology or botany.

A comparison of the courses in biology taught in the four-year colleges with those of the junior colleges, shows that the courses are similar except that the universities offer a broader range of courses. The pre-medic and pre-nursing requirements are similar. Courses in general biology are coming to be quite common. The University of California, Leland Stanford, Texas Christian University and Southern Methodist University are good examples as offering such a course for those who want a general training course.

GENERAL AND SPECIAL AIMS OF BIOLOGICAL SCIENCES

In making a curriculum for the biological sciences, varied groups according to their future needs should be considered. A great deal depends also on the size of the school system. The various groups found in junior college may be classified as follows: (a) Those desiring a general training; (b) Those preparing for medicine; (c) Those intending to prepare for nursing; (d) Those preparing to study for dental profession; (e) Those preparing for physical education directors; (f) Those expecting to enter agriculture or forestry; (g) Those who desire to specialize in the biological sciences either as research workers or as teachers of the science.

All of these require special training, and courses are built to fit their needs. The pre-medic student for example needs a great amount of zoology, while the man studying for agriculture desires botany, and so on for the other groups.

TABLE III. *Number of Junior Colleges Offering or Not Offering Biology.*

SIZE OF SYSTEM / No. OF TEACHERS	Public Colleges				Church Colleges				Private Colleges								
	Number offering Biology	Percentage of schools in group	No. not offering Biology	Percentage of schools in group	Number offering Biology	Percentage of schools in group	No. not offering Biology	Percentage of schools in group	Number offering Biology	Percentage of schools in group	No. not offering Biology	Percentage of schools in group	Total number offering Biology in group	Percentage of schools in group	Total number offering no Biology in group	Percentage offering no Biology in group	Grand Total of Colleges in group
8 or less	5	71.4	2	28.6	11	36	19	63.4	3	100	0	0	19	47.5	21	52.5	105
9 to 20 inclusive	28	93.3	2	6.7	54	77.1	16	22.9	5	100	0	0	87	82.8	18	17.2	105
21 or above	25	100	0	0	10	71.4	4	28.6	8	100	0	0	43	91.5	4	8.5	47
No. of teachers not given	3	100	0	0	5	83.3	1	16.6	0	0	0	0	8	88.8	1	11.2	9
Totals	61	95.3	4	4.7	80	66.6	40	33.3	16	100	0	0	157	78	44	22	201

PROPOSED COURSE FOR THE NEW UNIT

A proposed course of study for the new unit in our school system, as we suggested in the earlier part of this discourse, has been deduced from the courses as outlined above. The problem is to construct a curriculum in the biological sciences that is feasible for a unit of our school system consisting of a combination of the senior high school and junior college. In dealing with the many possibilities several factors enter into the making of curricula. In the first place, local conditions will influence the making of a curriculum. If it is the desire of the community to build a school, the chief purpose of which is to prepare students for college or university, this desire will materially affect the curriculum of the school. Courses will be offered that will fit the requirements of the colleges and universities. If preparation for the various trades or professions is desired, the system will still be affected differently. The greatest factor in deciding the courses that may be offered is the size of the school system.

The small system cannot accommodate all of the classes or groups of students. In the first place the demand for various courses would be limited in the small school, and in the second place, there are not enough teachers in such a system to permit specialization of teaching force for the various subjects in the curriculum. It seems best, therefore, that the small system offer at least one course of general biology which is especially adapted to the student desiring a general training, and let the pre-medic, pre-dental, and pre-nursing student get whatever benefit he can from the course. This course might be offered to freshman or sophomore college students and should be required of every student who has not had a course in biology in the high school. No individual who has had as much as two years of college work should go through life without some scientific knowledge of living things. To say the least, such an education would certainly not be a well-balanced one.

If the system is a little larger, for instance fourteen to sixteen teachers for the last two years of high school and junior college combined, then a full year of general botany and a year of zoology should be added. This scheme would give the pre-medic student a chance to get a fairly good foundation for his further study.

The church schools should be no exceptions. It is a blow to

Christianity for any denominational school to dodge the biological sciences for fear that some heretical doctrine of evolution might be taught. The people want to know the truth and they are going to know it. The persistence of some of these schools in shunning the actual facts as laid down in the rocks of God's earth will have a tendency to drive the young, thinking student away from Christianity rather than keep him ignorant of the truth and thus "save" him from the "rank heresy of evolution."

SUMMARY OF COURSE FOR SMALL SYSTEM

A brief summary of the course that should be offered in a small system is as follows:

With ten teachers (five high school and five college) six hours of general biology required of all students who have not had one year of biology in high school, and for all pre-medics, pre-nurse, pre-pharmacy, pre-agriculture, and pre-forestry students in the junior year (The junior year in the new system would be same as freshman college, senior year same as sophomore, etc.)

General Training Course:

6 hours general biology required of all juniors if no biology was taken in high school; in all others elective.

Pre-Medic Requirements:

6 hours general biology for sophomores (seniors in high schools).
6 hours botany for juniors.
6 hours zoology for seniors.

Pre-Nurses, Pre-Dentists and Pre-Pharmacists:

The same as pre-medics.

Pre-Agriculture and Pre-Forestry:

6 hours general biology for sophomores.
6 hours botany for juniors.

Pre-Teaching:

6 hours general biology for juniors.

Pre-Physical Education Director:

6 hours general biology sophomores.
6 hours zoology for juniors.

For Research Training:

Same as for pre-medics.

Total Offering for the Small Unit:

6 hours general biology.
6 hours botany.
6 hours zoology.

For the medium-sized system (18 to 40 teachers in the new unit system) the course can be broadened and enriched to some extent more than the one suggested for the small system Where the small school offers only general courses, the larger one can give more detailed and advanced work, and can add human physiology, bacteriology, and hygiene. This arrangement permits the pre-medic, the pre-dentist, etc., to get work that more adequately fits his needs.

SUMMARY FOR THE MEDIUM-SIZE SYSTEM

General Training Course:

6 hours general biology required of all juniors if no biology was taken in high school; all other courses elective for the general training student.

Pre-Medics. Pre-Dentists and Pre-Pharmacists:
6 hours general biology, sophomore year.
6 hours human physiology, junior year.
6 hours zoology, senior year.
Pre-Nurses:
6 hours general biology, sophomore year.
6 hours human physiology, junior year.
3 hours bacteriology, senior year.
3 hours hygiene, senior year.
Pre-Agriculture:
6 hours general biology, sophomore year.
6 hours botany, junior year.
6 hours zoology, senior year.
Pre-Forestry:
6 hours general biology, sophomore year.
6 hours botany, junior year.
Other courses elective.
Pre-Teaching:
6 hours general biology, junior year.
Other courses elective.
Pre-Physical Education Director:
6 hours general biology, sophomore year.
6 hours zoology, junior year.
6 hours human physiology, senior year.
Research Training:
6 hours general biology, freshman year.
6 hours botany, sophomore year.
6 hours zoology, junior year.
6 hours human physiology, senior year.
3 hours bacteriology, senior year.
Total Offerings for This Unit:
6 hours general biology.
6 hours botany.
6 hours general zoology.
6 hours human physiology.
3 hours human physiology.
3 bacteriology.

Finally, we come to the offerings and requirements for the large system with more than 40 teachers in the four-year unit. A total offering of 63 hours has been proposed for this sized school, which adequately cares for all the various groups of students. It will be noticed that there is an expansion of courses suggested in this scheme to cover a greater period of time in the student's life, gaining thereby a greater continuity and correlation of subject-matter than is found in the present-day American system of education. If the senior high school and the junior college are combined into one unit, there will be a gradual working out of curricula, so that a continuity of courses will prevail. Correlations will be made that will prevent the many unnecessary duplications found in present-day courses.

A new course, called a "Survey Course," can be introduced into the large system as an elective. Such a course was organized and directed by Dr. H. H. Newman in the University of Chicago for a "group of selected first-year students of superior intelligence. The survey course was designed to give capable students a preliminary view of the rich intellectual fields that lie before them, so that, on the one hand, all of their work shall have a large measure of unity and coherence, and, on the other hand, they will be able to decide early what particular subject they may wish more thoroughly to explore. Dr Newman, in conjunction with his collaborators, has written a book, "The Nature of the World and of Man," which is used successfully as a basal text for the course in the University of Chicago. Such a course, if taken hold of enthusiastically by the

teaching staff of the larger system, should be a splendid one for the large four-year unit about which we are here concerned. It should be given merely as an orientation course in science.

The outline of the course proposed for the large system is as follows:

GENERAL TRAINING COURSE

Six hours general biology required of all juniors who have had no biology in high school; other courses elective

Pre-Medics:

6 hours general biology for freshmen.
6 hours human physiology, sophomores.
6 hours invertebrate zoology, juniors.
6 hours comparative zoology, seniors.

Pre-Dentists and Pre-Pharmacists:

Same as pre-medics.

Pre-Nursing:

6 hours general biology, freshmen.
6 hours vertebrate zoology, sophomores.
6 hours anatomy of the human body, juniors.
3 hours hygiene, seniors.

Pre-Teaching:

6 hours general biology, juniors.
All other courses elective.

Pre-Physical Education Director:

6 hours general biology, freshmen.
6 hours vertebrate zoology, sophomores.
6 hours anatomy of the human body, juniors.
3 hours bacteriology, seniors.
3 hours hygiene, seniors.

Pre-Agriculture and Pre-Forestry.

6 hours general biology, freshmen.
6 hours invertebrate zoology, sophomores.
6 hours general botany, juniors.
6 hours economic zoology, seniors.

Research Training in Botany:

6 hours general biology, freshmen.
6 hours general botany, sophomores.
6 hours advanced botany, juniors.
6 hours bacteriology, seniors.

Research Training in Zoology:

6 hours general biology, freshmen.
6 hours human physiology or anatomy, sophomores.
6 hours invertebrate zoology, juniors.
6 hours vertebrate zoology, seniors.

Total Offerings for the Large System:

6 hours general biology.
6 hours general botany.
6 hours advanced botany (taxonomy).
6 hours invertebrate zoology.
6 hours comparative zoology.
6 hours economic zoology.
6 hours human physiology.
6 hours anatomy of the human body.
6 hours bacteriology.
3 hours hygiene.
6 hours survey course.

It will be noted from these outlines that the large system adequately provides for every group of students, while the small colleges are not able to offer as broad a curriculum as is necessary to fit every need of its various groups. The small school should, however, provide for the general training group and let the pre-medic, pre-nurses, and others get the most from it they can.

The Mathematics of General Inorganic Chemistry

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During recent years there have been several investigations as to the subject-matter of text books in general inorganic chemistry, but special study of the mathematics of these texts seems not to have been made. Surely there is mathematics involved in both the "senior chemistry" of the high school, and the "freshman chemistry" of the college. How much? Of what kind? In what chemical connections? Are the mathematical demands of college chemistry greater than those of high school chemistry? Such questions as these, it seemed, might be profitably answered.

Let there first be a general defense of the study. Possibly mathematics is of no importance in the presentation of general inorganic chemistry to beginning classes in high school and college. If one accepts Osborn's[1] objective he will have to search between the lines and in the hidden meanings for any recommendation that mathematics be used in teaching chemistry. The text book in this subject that omits mathematics altogether is yet to be written, however, and, as Powers[2] remarks: "It may be assumed, therefore, that the material included in the text-books is that which has been made the basis of instruction." There is mathematics in general inorganic chemistry texts, hence—presumably—in the courses offered from them. How many teachers leave out part or all of the mathematics, and how many add thereto, will never be known, though we have our own shrewd guess in the matter.

For the mathematics of general inorganic chemistry, therefore, we will study the textbooks.

1 Osborn, R. W., "Some Suggestions for Modifying the Content of High School Chemistry to Better Serve the Purposes of a Liberal Education," in Journal of Chemical Education, Vol. 2, pp. 737-742 (September, 1925). "We teach chemistry to our pupils so that they may become intelligent about the modern world in which we live, a world which is so conditioned by the contributions of modern chemistry and other sciences as to be non-understandable without such an insight as we try to supply. We believe that a course in chemistry ought to yield dividends in more intelligent citizens, improve public health, more wholesome and hygienic home conditions, a common-sense attitude towards nostrums of all kinds, both patent and political, and a genuine appreciation of the work of the chemist in serving the cause of humanity."

2 Powers, S. R., "A Diagnostic Study of the Subject Matter of High School Chemistry." Teachers College Contributions to Education, No. 149 (1924), page 241.

Technique of the Study

Fifteen inorganic chemistry texts of the high school level, and eighteen of the college level, all published within approximately ten years, were minutely examined page by page for instructions and problems that involved any mathematical operation. Data was recorded on cards in such a manner that the cards could be selected and arranged for any desired grouping of data.

The Scope of this Report

General conclusions and condensed data will be given here to conserve space. There will be no ranking of textbooks in any aspect, nor actual counts of pages or mathematical occurrences. Percentage figures will point out the important trends. There is on file, however, both raw and refined data to cover all of these points, if there should be inquiry concerning what here is left untold.

How Much Mathematics is Found in Chemistry Texts?

In comparison with the total amount of space in a book, mathematics shrinks to a most modest size. The most generous text was of college rank, with 4.1 per cent; the most parsimonious a high school text, granting but 0.3 per cent. The median proportion for high school texts is 1.2 per cent; for college texts, 1.3 per cent; for both combined, 1.2 per cent.

It is of interest to note, therefore, that college texts are no more liberal in proportion than high school texts in the amount of mathematics presented. There is only one college text that gives a greater amount (4.1%) than the most mathematical high school text (2.6%); there are but three high school texts that gives less than the least mathematical college text (0.7%). For practical purposes we might report that the attention to mathematics is equal in both high school and college texts in proportion to their size.

That this phrase "in proportion to their size" may not be a stumbling block, the typical number of pages which represents the total space for mathematics in a text is given:

For high school texts: 1Q, 3.66 pp.; Median, 6.35 pp.; 3Q, 7.91 pp.

For college texts: 1Q, 5.48 pp.; Median, 7.30 pp.; 3Q, 9.17 pp.

For both types: 1Q, 4.43 pp.; Median, 6.91 pp.; 3Q, 8.42 pp.

The typical college text, therefore, has approximately one

page more of actual mathematics — a scant deference indeed to the "college attitude" that might be thought to favor the third of the "Three R's."

How Well Is This Mathematics Distributed?

If ideals were under discussion, it would seem that the mathematics of chemistry might be distributed evenly throughout the entire text. It is common observation, however, that the greater concentration is in the first chapters of the typical book. This is putting it mildly; in many texts the idea seems to be "Get at it and get it over with!" in approaching the apparently unpleasant duty of presenting mathematics to the beginners.

The degree to which a distribution of material in a text approaches an ideal may be computed mathematically by means of Webb's Scatter Formula[3]. If ten per cent of the mathematics was presented in each one-tenth portion of the book, the Scatter Coefficient would be 100 per cent. Concentration rather than distribution, however, is shown by the following Coefficients of Scattering:

For high school texts, Q1, 19.5; Median, 24.2; Q3, 32.4.

For college texts, Q1, 21.9; Median, 27.7; Q3, 37.3.

For both types, Q1, 20.0; Median, 27.0; Q3, 33.1.

Such figures, if translated into more expressive though less precise words, would warrant the statement that about eighty-five per cent of the mathematics offered by chemistry texts is presented in the first third of the books.

What Type of Mathematics Is Used in General Inorganic Chemistry?

This question may be answered almost in a single word — *proportion.* Experienced teachers of chemistry have long suspected this condition — here we have proof. In two aspects the figures are significant: (1) the relative amount of space each type of mathematics takes in composing the whole; (2) the relative number of occurrences of each type in making the sum total of all mathematical insertions. This information follows:

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3 See Webb, H. A., George Peabody College Contributions to Education, No. 4, Part 1, page 26. The formula is

$$\frac{100{,}000}{S(\%^2)} = \text{per cent of distribution, or Scatter Coefficient}$$

in which $S(\%^2)$ represents the sum of the separate per cents of mathematics in each one-tenth portion of a text.

The Mathematical Topics; Their Relative Percentage of Space

In high school texts: Proportion, 88.3%; addition, 4.4%; multiplication, 3.8%; division, 2.6%; algebra, 0.5%; subtraction, 0.4%.

In college texts: Proportion, 84.8%; multiplication, 6.7%; addition, 4.6%; equations, 1.7%; division, 1.6%; logarithms, 0.4%; algebra, 0.2%.

In both types of texts: Proportion, 86.2%; multiplication, 5.7%; addition, 4.6%; division, 1.9%; equations, 1.0; algebra, 0.3%; logarithms, 0.2%; subtraction, 0.1%.

The Mathematical Topics: Their Relative Percentage of Occurrence

In high school texts: Proportion, 87.5%; addition, 5.3%; multiplication, 3.6%; division, 2.1%; subtraction, 1.0%; algebra, 0.1%.

In college texts: Proportion, 77.3%; multiplication, 10.3%; addition, 6.4%; equations, 2.6%; division, 2.6%; algebra, 0.4%; logarithms, 0.4%.

In both types of texts: Proportion, 82.1%; multiplication, 7.3%; addition, 5.9%; division, 2.3%; equations, 1.4%; algebra, 0.4%; subtraction, 0.4%; logarithms, 0.2%.

It is indeed significant, from a teaching standpoint, that over four-fifths of the total mathematics presented in texts of general inorganic chemistry involved merely the principles of simple proportion. Has it not been said that the mathematics of chemistry has caused more failures than any other feature of the course? If this be true, it can only follow that students do not know simple proportion, and if they do not understand simple proportion they are unprepared for general chemistry. Such a matter, it would seem, could be remedied easily by adequate drill in this particular branch of mathematics, which can hardly be considered as of unusual difficulty. If the proposition be really as simple as our tables would indicate, effort should be specifically directed toward this handicap to students of chemistry.

What Chemical Topics Receive Mathematical Treatment?

The authors of general inorganic chemistry texts, through some wholly intangible unifying power, have selected a rather restricted list of chemical topics for mathematical treatment. There has, of course, been no collusion, but the fact is that

in the thirty-three texts there are but forty-two different mathematical applications to chemistry. A condensed table follows:

The Chemical Topics: Their Relative Percentage of Space

In high school texts: How much? 29.5%; molecular weights, 16.5%; computing formulas, 8.5%; Charles' law (alone), 7.4%; gas laws (combined), 7.2%; percentage composition, 6.2%; Boyle's law (alone), 4.2%; titration, 2.9; atomic weights, 2.1%; combining weights, freezing points, mass action, multiple proportions, thermo-chemistry, volume to weight (or vice versa), valence, 1.8% to 1.0%; Avogradro's law, vapor pressure, radioactivity, F.° to C.° and C.° to F.°, humidity, density, specific gravity, Faraday's law, equivalent weights, definite proportions, Dulong and Petit, number of molecules, 0.9% to 0.1%.

In college texts: How much? 18.3%; mass action, 12.3%; computing formulas, 10.5%; gas laws (combined), 8.6%; Charles' law (alone), 8.5%; molecular weights, 8.2%; titration, 5.2%; Boyle's law (alone), 4.0%; percentage composition, 3.7%; freezing points, 3.2%; Dalton's law, 2.5%; multiple proportions, Dulong and Petit, Faraday's law, density, 1.9% to 1.0%; combining weights, gas diffusion, number of molecules, kinetic theory, F.° to C.° and C.° to F.°, humidity, atomic weights, Avogado's law, pH. values, Graham's law, electrochemistry, van der Waal's law, vapor pressure, degree of ionization, Henry's law, van't Hoff's law, osmotic pressures, equivalent weights, law of gravity, thermo-chemistry, definite proportions, specific gravity, radioactivity, valence, changing fractions to decimals, 0.9% to 0.1%.

The combined tabulation will not be given, save to note that three chemical topics embrace more than half the mathematical attention of all texts in general inorganic chemistry: how much? 21.9%; all reference to gas laws, 19.6%; molecular weights, 10.5%.

The Chemical Topics, Their Relative Percentage of Occurrence

In high school texts: gas laws (all references), 18.3%; molecular weights, 17.7%; how much? 16.7%; all others, less than 10%.

In college texts: gas laws, 15.9%; molecular weights, 13.3%; how much? 11.5%; computing formulas, 10.1%; all others, less than 10%.

In both types of texts: gas laws, 17.3%; molecular weights, 12.8%; how much? 11.2%; all others, less than 10%.

College texts present a decidedly greater variety of chemical topics with mathematical treatment than do the high school texts. This, no doubt, is what the freshman has long ago suspected. In this factor alone, however, does the college text differ from that of the lower level. It would appear — and our unpublished data bear out the asumption, — that the college text gives more topics, but no more space to those it presents jointly with the high school books. The college text offers somewhat wider, but no deeper, mathematical treatment.

Physics still rides the chemist hard. If he could get his physics taught beforehand, he might have time for some neglected chemistry. A glance at the large number of mathematical topics that are strictly of a physical nature will bear this out. This, too, is particularly true in the college texts. It was a wise college professor who included the topic, "how to change fractions to decimals," in his college text; it would be a foolish one who did not devote approximately one half of his mathematical space to laws and principles that should have been taught in physics.

The Chemical Elements that Supply Mathematical Experience

Any element, of course, would serve to practice upon in gaining skill in chemical mathematics. Certain elements, however, seem to have been selected for some aspect of their suitability. For most of these, experienced teachers of chemistry will see the reasons behind the choice. The following tables might supply arguments for special attention to the numerical aspects — atomic weights, valence, and the like — of a small group of chemical elements.

The Chemical Elements: Their Relative Percentage of Space in Mathematical Topics

In high school texts: oxygen, 32.0%; hydrogen, 18.3%; chlorine, 12.8%; sulfur, 7.8%; potassium, 7.1%; carbon, zinc, iron, mercury, nitrogen, manganese, sodium, 4.7% to 1.1%; copper, calcium, silver, lead, phosphorus, barium, chromium, lithium, gold, 0.8% to 0.1%.

In college texts: oxygen, 29.9%; hydrogen, 19.7%; chlorine, 9.8%; sulfur, 8.2%; carbon, 6.8%; potassium, 5.2%; zinc, copper, nitrogen, iron, sodium, calcium, phosphorus, 4.0% to 1.1%; magnesium, iodine, lead, tin, silver, mercury, aluminium, silicon, manganese, gold, chromium, barium, 0.8% to 0.1%.

The combined tabulation will not be given, save to note that three chemical elements are utilized in more than one-half of the space devoted to chemical mathematics in inorganic chemistry texts: oxygen, 29.0%; hydrogen, 20.2%; chlorine, 10.9%.

The Chemical Elements: Their Relative Percentage of Occurrence in Mathematical Topics

In high school texts: oxygen, 27.9%; hydrogen, 14.4%; all others, less than 10%.

In college texts: oxygen, 25.6%; hydrogen, 13.5%; all others, less than 10%.

In both types of texts: oxygen, 24.6%; hydrogen, 12.7%; all others, less than 10%.

Only twenty-six elements are utilized as illustrations of mathematical principles in general inorganic chemistry texts. High school and college texts give approximately the same attention to most of these elements; the assumption that they offer the same problems is decidedly well founded.

The Chemical Compounds that Supply Mathematical Experience

Chemical mathematics, like chemical experiment, frequently deals with specific compounds. The rather large amount of physics that is taught in these texts of chemistry is sometimes presented without any chemical peg, yet the chemical author usually prefers — from conscience, no doubt — to work his problems with real chemical compounds named in the problem. Each of the many thousand combinations would serve a variety of mathematical needs, yet the authors have been decidedly partial to a very few of them, and the tables below show:

The Chemical Compounds: Their Relative Percentage of Space in Mathematical Topics

In high school texts: potassium chlorate, 16.3%; water, 13.2%; sulfuric acid, 12.9%; hydrochloric acid, 5.8%; mercuric oxide, 5.4%; forty-five other compounds, less than 5%.

In college texts: water, 10.9%; potassium chlorate, 10.0%;

sulfuric acid, 5.7%; hydrochloric acid, 5.5%; fifty-eight other compounds, less than 5% each.

In both types of texts: potassium chlorate, 14.6%; water, 13.9%; sulfuric acid, 11.2%; hydrochloric acid, 5.6%; seventy-two other compounds, less than 5% each.

The Chemical Compounds: Their Relative Percentage of Occurrence in Mathematical Topics

In high school texts: water, 14.6%; sulfuric caid, 12.7%; potassium chlorate, 9.7%; hydrochloric acid, 7.8%; forty-six other topics, less than 5% each.

In college texts: potassium chlorate, 13.4%; sulfuric acid, 12.7%; potassium chlorate, 9.7%; hydrochloric acid, 7.8%; forty-six other topics, less than 5% each.

In college texts: potassium chlorate, 13.4%; sulfuric acid, 7.8%; hydrochloric acid, 7.4%; copper oxide, 5.6%; fifty-eight other compounds, less than 5% each.

In both types of texts: water, 14.1%; sulfuric acid, 10.0%; potassium chlorate, 8.3%; hydrochloric acid, 6.8%; seventy-two other compounds, less than 5% each.

Conclusions

(1) There is comparatively little mathematics presented in our present texts of general inorganic chemistry.

(2) Such mathematics as is present is concentrated to a high degree in the first chapters of the texts.

(3) Simple proportion is the principle of mathematics used almost to the exclusion of other forms in general inorganic chemistry. This being true, it would appear that such foundation of drill and clear understanding might be laid that no student should suffer mathematical handicaps in his beginning chemistry course.

(4) The question "How much?" is the vehicle on which most of the chemical mathematics is brought into a course; the "gas laws" are close behind. Chemistry and physics, therefore, are each represented.

(5) The most popular chemical elements for mathematical treatment are oxygen, hydrogen, and chlorine; the compounds that serve mathematics best are potassium chlorate, water, and sulfuric acid.

(6) The treatment of mathematics in high school and in college textbooks of inorganic chemistry is strikingly similar in relative amount, type, and applications.

Chemistry for Fun

RALPH E. DUNBAR

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The old adage that, "all work and no play makes Jack a dull boy," is quite as applicable to the study of chemistry as to other forms of human activity. Every experienced teacher has repeatedly noticed that innate tendency of many if not most chemistry students to often want to play and "experiment" rather than to perform the assigned exercises and problems. The author has no inclination or desire to turn the chemistry laboratory or lecture table into a vaudeville stage and conduct or permit regular performances of this nature. Likewise, we are quite as unwilling to accept the philosophy that an experiment is necessarily poor because it may be slightly spectacular. Such exercises and demonstrations, if used sparingly and wisely, may tend to increase and hold student interest in the laboratory phases of the science. However, the suggestions contained in the following bibliography are offered primarily for other uses, rather than class room instruction. Instructors and students frequently find it necessary or desirable to present stunt programs before their science clubs, assembly groups, or similar gatherings. The following references will be found to be especially helpful in such cases and this bibliography was prepared essentially with this thought in mind. However, many of these same demonstrations may be used to good advantage in regular instructional work. There is no reason why such a program may not be delightfully entertaining and instructive as well.

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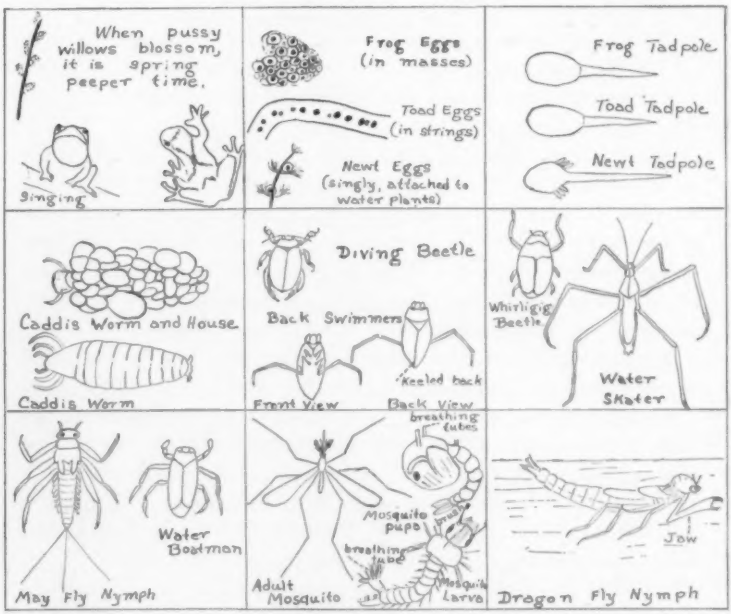
Easy There! The Peepers Are Peeping[1]

DOROTHY A. TREAT,
Cleveland Museum of Natural History.

When pussy-willow buds glow pink through their satiny fur, it is spring-peeper time in the swamps and marshes. On warm afternoons, tiny frogs, so small they could perch with ease on one's thumb, and marked on the back by a large cross which distinguishes them as *hyla pickeringi* or true spring peepers,



are puffing out their throats like balloons and singing loudly.

Spring peeper time is also egg and tadpole time. If you would raise some of these amphibians at home, get out a strainer, small pails or Mason jars, and rubber boots, and proceed to the pools of low, wet woodlands. Amphibian eggs are always encased in jelly. Great masses of jelly with dark specks inside are frog eggs. Long ribbons of jelly containing small dark specks are toad eggs. Salamander eggs, or more prop-

1 From "School Topics," Cleveland Public Schools, March 18, 1930.

erly speaking, newt eggs, occur singly and are attached to twigs, leaves or water plants. These eggs are often hard to find.

Tadpoles as well as eggs will be caught in the strainer. Those of the newts are easy to recognize by the bunches of gills which stick out from the back of the head like small fingers. Toad and frog tadpoles are similar at first, but as they become older the toad tadpoles usually become darker, while the frogs grow lighter and appear speckled.

THEY'RE FOND OF SALADS

Tadpoles are vegetarians, and should be fed bread crumbs, cookie crumbs, bits of apple and lettuce. Pond water is better for them than tap water, for it usually contains some natural food and is freer from harmful chemicals.

Amphibians, however, form only a part of the life of ponds and woodland pools. A few scoops with the strainer will bring to view a variety of water insects, whose behavior makes an interesting study. On the surface of the water whirligig beetles gyrate about in a dizzy fashion, and long-legged water-skaters skim the surface with their small black bodies swinging below their "knees" like little suspension bridges.

Swimming about through the water are big, oval-shaped diving beetles, propelling themselves with long hairy legs. They carry their air supply with them in a tiny bubble at the end of the body. The more elongated water boatmen row through the water with a pair of long hind-legs. Back-swimmers dart about, back-side down, stroking like oarsmen. If you examine them carefully, you will discover that the back is keeled like a boat to facilitate their movements in the water.

CARRY HOUSES WITH THEM

Many larvae are present in the ponds. Caddis worms crawl about carrying houses on their elevated tails.. These houses are made by the larvae out of stones, sticks, bits of leaves, or whatever is at hand. It is possible, with care, to remove the old houses and by furnishing building materials to watch the larvae construct a new home. Mayfly nymphs, which become "Canada Soldiers," are frequently found creeping about over brownish stones which they match exactly in color.

All these creatures, if kept in a sand-bottomed aquarium with water plants, make an interesting but unfortunately not always a happy community. Some battles are certain to occur, and the victor will eat the spoils.

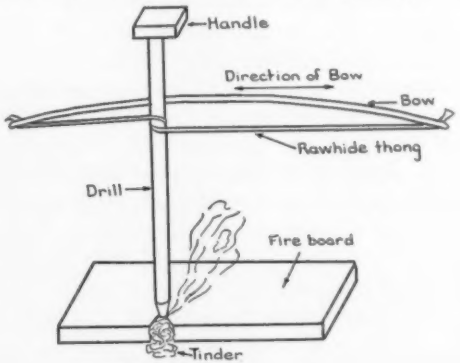
Fire Kindling[1]

JOSEPH R. LUNT and DENNIS C. HALEY
Teachers College of the City of Boston, Massachusetts.

The following experiments, showing different methods of fire kindling, never fail to arouse the interest and enthusiasm of general science classes. With a little practice any teacher can perform them.

EXPERIMENT 1. USE OF BOW AND DRILL.

The best material for kindling a fire with a bow and drill is Yucca wood, which grows on the plains and foothills of New Mexico and Arizona. Yucca surpasses all other woods in the quickness and ease with which it may be used to make fire. The Indians of the Southwest used it to make fire by friction long before the white man entered their country.



UNIT 4 Prob. II

Take the Yucca fireboard. Lay it on the floor. Now take a small amount of finely shredded tinder. Flatten it out and place it under the slot in the fireboard. Take the bow and drill. Twist the leather thong around the drill once. Put the blunt end of the drill into the slot in the fireboard. Place the drill socket over the other end of the drill. Hold the drill in place, erect, with the left hand. Keep the fireboard firm on the floor with the left foot. Kneel down on one knee. Grasp the end of the bow with the right hand. Move the bow in a horizontal

1 The illustrations and much of the text for this article are from the manual to accompany the Lunt and Haley Demonstration Units, and are used here by courtesy of the L. E. Knott Apparatus Company.

position back and forth, so that the leather thong makes the drill rotate. Do this slowly at first. Now move the bow faster and increase the pressure on the drill a little. If the thong slips on the drill, it should be tightened. It is not a good plan, however, to have the thong too tight. Notice that the board begins to smoke. Friction has heated the board so hot that sparks of the glowing carbon fall out of the slot into the tinder.

Lay the bow and drill aside. Lift the fireboard carefully, so as not to disturb the sparks. Pick up the tinder. Fold it around the sparks carefully, leaving a small opening. Blow through this opening onto the sparks. Notice that the tinder begins to smoke. Continue to blow, first gently, and then more forcefully, until the tinder bursts into flame. Take care that you do not blow the sparks out of the tinder. Keep folding the tinder back of the sparks. Drop the burning tinder onto an aluminum plate. With a little practice, you will be able to judge how long to rotate the drill. Only a few rapid turns are necessary. When necessary, cut more slots in the fireboard similar to the first one.

In this experiment, friction between the drill and fireboard produces sufficient heat to kindle the pieces of carbon which are ground out of the fireboard. The tinder is finely shredded, so that it can be easily raised to the kindling temperature. When held loosely, a generous supply of oxygen in the air surrounds the fine shreds of tinder and helps it to take fire quickly.

EXPERIMENT 2. USE OF FLINT AND STEEL.

With scissors cut a four-inch square of cotton cloth. Hold the cloth by one corner with the crucible tongs and set fire to it. Let the cloth burn until it is black and well charred. Drop it on an aluminum plate as soon as the flame begins to die down. Press the bottom of a second plate onto the charred cloth to put out the flame. Take care that all sparks are extinguished.

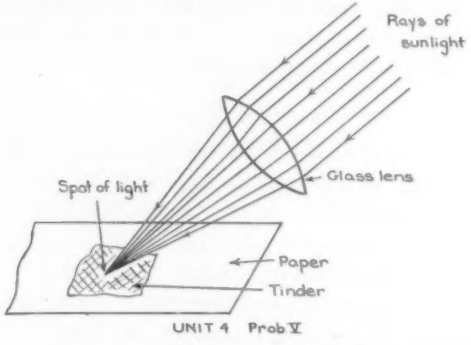
Take a piece of tissue paper. Place the charred cloth or tinder on the paper. Press it down flat. Take one of the stones in the left hand and the file in the right. Strike the stone a quick, glancing blow with the flat side of the file. This should produce several sparks. Practice until you are able to get good sparks. Now hold the stone above the tinder and direct the sparks onto the tinder. As soon as a spark causes

the tinder to glow, pick up the paper, fold it around the tinder, and blow gently. When smoke appears, blow harder, until the paper bursts into flame. Drop the burning paper onto an aluminum plate.

The sparks are small pieces of glowing steel heated red hot by friction. The charred threads of tinder are small, well surrounded with oxygen, and are easily raised to the kindling temperature.

The use of tinder constitutes one of the earliest methods employed to obtain fire. The brightly polished tinder box occupied an important position on the mantel of fireplaces in old kitchens. Each night the tinder was prepared for the following day. Pieces of linen and cambric were charred or burned and then placed in the tinder box. The box was then covered to keep the tinder dry. The fuel was fired was striking flint and steel together and directing the sparks onto the tinder.

Flint and other stones were used by the American Indians to kindle fires with dried bark or partially decayed vegetable matter as tinder. Even at the present time some people, such as the Eskimos, start fires by striking quartz and iron pyrites together. The sparks are allowed to fall upon moss which has been dried and rubbed vigorously between the hands.



EXPERIMENT 3. KINDLING FIRE WITH A LENS.

Prepare tinder as in Experiment 2. Place a piece of tissue paper on a table or a window sill, where the sun's rays fall directly on it. Lay a piece of charred cloth or tinder on the paper. With the lens, focus the sun's rays onto the tinder. Move the lens back and back and forth a few inches from the

tinder, until the sun's rays coming through the lens are focused on the tinder. Hold the lens steady in this position until the tinder begins to glow. Fold the paper around the tinder. Blow gently at first, and then harder, until the paper bursts into flame. Drop the burning paper onto an aluminun plate.

The heat from the sunlight passing through the lens is concentrated at one spot. This heat is sufficient to make the tinder glow. The amount of heat received by the earth from the sun in a year would, if evenly distributed over all latitudes, melt a layer of ice 124 feet thick over the entire surface of the earth.

EXPERIMENT 4. USING CHEMICAL ACTION TO START A FIRE.

Put one-quarter of a teaspoonful of powdered sugar and an equal amount of potassium chlorate in an evaporating dish. Mix them well. Place the mixture on an aluminum plate. Lower one end of a piece of glass tubing into a bottle of sulphuric acid, to a depth of half an inch. Put one finger firmly over the open end of the tube, so that a small quantity of acid is held in the tube. *Caution—Stand at arm's length from the mixture on the plate.* Drop the sulphuric acid on the mixture. Notice that it starts to burn vigorously.

This action was started by the chemical action of sulphuric acid on sugar. The potassium chloride furnished most of the oxygen necessary for combustion.

EXPERIMENT 5. HOW THE FIRST CHEMICAL MATCHES WERE MADE.

Put one-eighth of a teaspoonful of sugar and the same quantity of potassium chlorate in an evaporating dish. Mix them well. Spread the mixture out a little. Light a candle. Let several drops of melted paraffin fall on the mixture. *Caution—Keep the candle flame at least four inches away from the mixture.* With the fingers, work some of the melted paraffin and chemicals into a small ball about the size of a pea. Stick the small ball firmly onto the end of a splint. Pour a little sulphuric acid into another evaporating dish. Dip the end of the splint with chemicals on it into the sulphuric acid in the evaporating dish. Remove the splint from the evaporating dish. Hold it at arm's length and watch it burn. The cause

of the fire in this case is chemical action. The flame sets fire to the wooden splint and the match burns.

The first chemical match was invented in Paris in 1805. It was simply a wooden splint tipped with sulphur and an ignition mixture of sugar and potassium chlorate. It was fired by dipping it into a bottle of asbestos moistened with sulphuric acid. This type of match was followed by the so-called Prometheans in 1826. These were made as follows: A small quantity of potassium chlorate and sugar was rolled up tightly in a piece of paper, and a small sealed glass tube containing a bubble of sulphuric acid was placed inside. Two pairs of pliers were sold with these matches. One pair was used to grip the match and the other pair to fracture the glass containing the sulphuric acid. The Prometheans were soon replaced by another match. In 1827, John Walker, an English druggist, produced a match which was a wooden splint tipped with sulphur and an ignition mixture of one part potassium chlorate and two parts antimony sulphide. It was fired by drawing it vigorously across a piece of sandpaper, or emery paper, held between the thumb and finger. The first completely successful friction match was produced in 1831, by Dr. Sauria, a Frenchman. From that time on, inventors have been busy with different ideas to perfect friction matches. As a result, there are now many satisfactory types of matches on the market.

Bird-Banding Studies Cover Century

Bird banding in the United States dates from the time of Audubon, who about 1803 marked a brood of phoebes with silver wire, and was rewarded the following season when two of the banded birds returned to nest in the same vicin[i]ty. Since then more than 400,000 have been banded in the United States and Canada by co-operators of the United States Biological Survey. Under the migratory bird treaty act, anyone who bands birds must have a Federal permit.

National Association for Research in Science Teaching

ATLANTIC CITY MEETING, FEBRUARY 24TH AND 25TH, 1930.

REPORT OF SECRETARY-TREASURER.

The third annual meeting of the National Association for Research in Science Teaching was held at the Ritz-Carlton Hotel in Atlantic City on February 24th and 25th, 1930. The program was presented as printed in the January issue of Science Education.

BUSINESS MEETING

Following the dinner meeting in the Blue Room of the Ritz-Carlton Hotel, President W. L. Eikenberry called the members of the Association to order for their annual business meeting.

The report of the Secretary-Treasurer was read and approved.

Balance on hand February 25, 1929			$66.00
Received dues, 1929-1930			78.00
Total			$144.00
Bills paid:			
To W. G. Whitman			
1000 Programs, Dec. 27, 1929	$18.50		
Postage, 500 programs to E. R. Glenn	.31		
Postage, 500 programs to S. R. Powers	.31		
Total		$19.12	
To office of Secretary-Treasurer			
Postage		2.28	
Total expenditures			$21.40
Balance on hand February 24, 1930			$122.60

It was regularly moved and seconded that:

1. All persons whose names were on the original list to whom notices were sent of the meeting that was held in Boston and who responded favorably and subsequently paid dues for the first year should be listed as charter members. The motion was passed by unanimous vote.

2. All papers presented at meetings of this Association shall be presented with the understanding that if the paper is to be published the Association shall have first claim to it. The motion was passed by unanimous vote.

The report of the Committee on the Constitution and By-Laws, consisting of E. E. Wildman, chairman, N. Henry Black, and H. A. Webb, was presented by the chairman. Mimeographed copies of the report had previously been placed in the hands of the members. With some modification the Constitution and By-Laws were unanimously approved. The final draft is given in this report.

The report of the Committee on Publications, consisting of Charles J. Pieper, chairman, Earl R. Glenn, and W. G. Whitman, was given by the chairman. Alternative proposals for the support of the Journal were made. On recommendation of the Committee it was unanimously voted that:

1. The Association should exercise the option which it holds on Science Education and purchase it from the owner, Mr. W. G. Whitman.
2. The responsibility for financial support of the Journal shall be vested with the Publications Committee, who shall solicit support for the Journal from such sources as are available.
3. The supporters of the Journal shall share its losses and its profits.
4. The present Publications Committee shall continue in its present capacity until a new committee is appointed by the Executive Committee.

The report of the Nominating Committee, consisting of Ellis C. Persing, chairman, C. E. Baer, and Morris Meister, was given by Mr. Baer. Nominations were as follows:

For President ..... Ellliot R. Downing
For Vice-President ..... Francis D. Curtis
For Secretary-Treasurer ..... S. Ralph Powers
For Members of the Executive Committee:
W. L. Eikenberry
Ralph K. Watkins

Following the report it was moved and passed that the nominations be declared closed and that the Secretary be instructed to cast a unanimous ballot in favor of the nominations made by the Committee.

The meeting adjourned.

Constitution and By-Laws of The National Association for Research in Science Teaching

CONSTITUTION

ARTICLE I
NAME

This organization shall be known as the National Association for Research in Science Teaching.

ARTICLE II
OBJECT

The object of this Association shall be to promote efficient teaching of science.

ARTICLE III
OFFICERS

Section 1. The officers shall be a President, a Vice-President, and a Secretary-Treasurer, who, together with two other members at large, shall constitute an Executive Committee. All shall be elected annually by the Association.

Section 2. No officers except the Secretary-Treasurer shall be eligible for the same office for more than three consecutive years.

Section 3. Members at large shall hold office but one year and are not eligible for re-election as members at large.

ARTICLE IV
MEETINGS

This Association shall hold an annual meeting at the same time and place as the annual meeting of the Department of Superintendence of the National Education Association, unless otherwise arranged by the Executive Committee.

ARTICLE IV
MEMBERSHIP

This Association shall have unlimited membership among those who by training and work have shown their interest in the efficient teaching of science and who have demonstrated ability in the field of educational research whether in the Elementary School, the Junior or Senior High School, the College, or the Teacher Training School. Individuals who have contributed outstanding service of any nature may, upon recommendation of the Executive Committee and approval of members, be admitted to membership.

ARTICLE VI
PUBLICATION

This Association shall publish, or cause to be published, for the benefit of its members and others, selected articles, reviews or reports of research which will tend to promote efficient science teaching.

ARTICLE VII
DUES

The dues of this Association shall be five dollars per year, payable at the time of the annual meeting.

ARTICLE VIII
LIFE MEMBERS

Any regular member of the Association shall be eligible to election as a life member. The dues for life membership shall be one hundred dollars.

ARTICLE IX
AMENDMENTS

This Constitution may be amended by a two-thirds vote of the members present at any annual meeting, provided printed notice of the proposed action and a copy of the proposed amendment has been sent to the members at least a month prior to such annual meeting.

BY-LAWS

ARTICLE I

OFFICERS AND COMMITTEES

Section 1. The President shall preside at all meetings and be *ex-officio* member of all committees.

Section 2. The Vice-President shall preside at all meetings in the absence of the President, and shall be chairman of the Executive Committee.

Section 3. The Secretary-Treasurer shall keep all the minutes and have custody of all books and papers relating to the Association; issue notices of all meetings and notify candidates of election.

Section 4. The Secretary-Treasurer shall keep an account of the receipts and expenditures, and shall pay bills only on order of the President. He shall make a report to the Association at the annual meeting, which may direct that the report be published.

Section 5. The Executive Committee shall conduct the usual business of the Association, and shall publish reports of officers and standing committees at their discretion.

Section 6. The Executive Committee shall appoint annually a committee to arrange for the program of the next annual meeting. The Secretary-Treasurer shall be *ex-officio* member of the program committee.

Section 7. The Executive Committee shall appoint annually a Publication Committee who shall have charge of all publications representing the Association, or issued in its name.

ARTICLE II

MEMBERSHIP

Section 1. The names and addresses, together with an abstract of the qualifying activities, of proposed new members shall be sent to the Secretary in writing. All such names shall be submitted to the Executive Committee for consideration and nomination for membership. Those nominated shall be voted upon by the Association at the next annual meeting.

Section 2. All resignations shall be sent to the Secretary in writing.

ARTICLE III

DUES

Section 1. Any member failing to pay dues within six months after being duly notified shall forfeit the right to membership.

ARTICLE IV

ELECTORS

Section 1. At or before the regular annual meeting, the President shall appoint a committee of three to nominate officers, including members of the Executive Committee, for the ensuing year; this list, together with names suggested from the floor, shall be presented at a regular session and voted upon by ballot.

ARTICLE V

AMENDMENTS

Section 1. The By-Laws may be amended only at the annual meeting after notices have been given to the members. No amendment shall be adopted except by a two-thirds vote of those present.

MEMBERS OF THE NATIONAL ASSOCIATION FOR RESEARCH IN SCIENCE TEACHING

*C. E. Baer
343 State Street
Rochester, N. Y.

*N. H. Black
Jefferson Laboratory
Harvard University
Cambridge, Mass.

*Wilbur Beauchamp
School of Education
University of Chicago
Chicago, Ill.

*Herbert Brownell
University of Nebraska
Lincoln, Nebraska

*Otis W. Caldwell
Teachers College
New York City

*Harry A. Carpenter
Dept. of Public Instruction
Rochester, New York

*Gerald S. Craig
Horace Mann School
New York City

*H. A. Cunningham
State Normal School
Kent, Ohio

*Francis D. Curtis
University High High School
Ann Arbor, Mich.

*E. R. Downing
School of Education
University of Chicago
Chicago, Ill.

*W. L. Eikenberry
State Teachers College
Trenton, N. J.

*W. Charles Finley
State Teachers College
Montclair, N. J.

*J. O. Frank
State Normal School
Oshkosh, Wisconsin

*Earl R. Glenn
State Teachers College
Montclair, N. J.

*John Hollinger
Dept. of Public Instruction
Pittsburgh, Pa.

*T. C. Jean
State Teachers College
Greeley, Colorado

*Homer W. LeSourd
Milton Academy
Milton, Mass.

*Joseph R. Lunt
Boston Teachers College
Boston ,Mass.

*Morris Meister
New York Training School
for Teachers
135th St. and Convent Ave.
New York City

*Ellsworth S. Obourn
John Burroughs School
St. Louis, Mo.

*E. Laurence Palmer
Cornell University
Ithaca, N. Y.

*Ellis C. Persing
Cleveland School of Education
Cleveland, Ohio

*Charles J. Pieper
New York University
Washington Square
New York City

*S. R. Powers
Teachers College
New York City

*F. A. Riedel
Teachers College
Columbia University

*W. F. Roecker
Boys' Technical High School
Milwaukee, Wisconsin

*C. L. Thiele
Supervisor of Science
Board of Education
Detroit, Mich.

*Morris Van Cleve
Supervisor, Nature Study
Board of Education
Toledo, Ohio

*Ralph Watkins
University of Missouri
Columbia, Missouri

* Charter members. † Elected in 1928. ‡ Elected in 1929.

*H. A. Webb
George Peabody College
for Teachers
Nashville, Tenn.

*W. G. Whitman
State Normal School
Salem, Mass.

*E. E. Wildman
Office of the City
Superintendent of Schools
Philadelphia, Pa.

†A. W. Hurd
Institute of School Experimentation, Teachers College
Columbia University, N. Y.

‡W. W. Knox
State Dept. of Education
Albany, N. Y.

‡Ralph E. Horton
Seward Park High School
New York City

‡Florence G. Billig
Board of Education
Sacramento, Calif.

‡Clarence M. Pruitt
University of Alabama
University, Alabama

‡J. A. Drushel
New York University
Washington Square East
New York City

Spontaneous Combustion is Subject of Research

Recognizing the economic importance of spontaneous combustion of farm products, the United States Department of Agriculture has begun research on this subject. Quantities of alfalfa hay in storage at the department's experimental farm at Beltsville, Md., are being studied under conditions believed to be ideal for spontaneous heating and to simulate as nearly as possible conditions on farms.

Losses from spontaneous ignition and spontaneous heating of farm products amounts to many millions of dollars every year, according to Dr. W. W. Skinner, of the Bureau of Chemistry and Soils. Agricultural products subject to this phenomenon include hay, grain, feeds, fertilizers, and farm manures.

"Although it is an established fact that spontaneous heating and ignition occur in certain products, very little is known concerning the exact cause," Dr. Skinner says. "Improperly cured hay, especially the legumes, when stored in large piles will heat spontaneously. Under certain conditions this heating will progress until the dangerous temperature of ignition is reached. It is generally believed that the initial heating is caused by the action of micro-organisms. The bacteria are eventually killed by the heat which they produce, at a maximum temperature somewhere in the neighborhood of 160° F. It is thought that the subsequent higher temperatures developed in the hay are the results of chemical reactions."

The New Books

New Practical Physics—1929—Newton Henry Black and Harvey Nathaniel Davis—645 pages—The Macmillan Co.

This book is a revision and an enlargement of a previous volume entitled "Practical Physics" by the same author. The senior author is Assistant Professor of Education at Harvard University. The junior author is President of Stevens Institute of Technology.

Several outstanding changes appear in the new book. The subject matter has been brought up to date by numerous text references to recent developments in the field of industrial physics, and many new pictures and diagrams which, for the most part, emphasize the interrelation of physics with modern life.

Among the important changes in the body of the text made in the revision are the following. The material on "Work, Power and Friction" has been removed from the chapter on "Simple Machines" and placed in a new chapter by the foregoing name. A new and interesting chapter entitled "Liquids and Gases in Motion" follows two newly titled chapters, "Pressure in Liquids" and "Pressure in Gases." Considerable strength has been added to the chapter on "Heat Engines" by several fine diagrams and illustrations. The treatment of electricity has been improved in several ways. The material formerly treated under a chapter entitled "Electric Currents" has been divided and a new chapter called "Electric Circuits" added. In the revision the older chapter on "Effects of an Electric Current" has been divided into two new chapters called respectively, "Magnetic and Chemical Effects of Electric Current," and "Electric Power, Heating and Lighting." In a similar manner, material of the previous edition written in the chapter on "Induced Currents" has been considerably enlarged and made into two new chapters called "Electric Generators and Motors" and "Induction Coils and Transformers." The material on sound and light has been considerably enlarged and brought up to date with the inclusion of some excellent diagrams and illustrations. A new chapter has been added on "Radio Telegraphy and Telephony," which adequately treats this subject from the high school point of view.

The book is modern in its point of view, in that stress is placed upon the application of the principles of physics and their utility in providing an intelligent background for the interpretation of environmental phenomena rather than upon the mere abstract phases of the subject.

There are included in this, as in the previous edition, concise summaries at the end of each chapter, which make for rapid and effective review. The mathematical aspects of the subject are well balanced. The problems are carefully selected and in nearly every case are genuine, involving a real situation. A very important aspect of the book is the inclusion of questions, separate from the problems, which are designed to send the pupil out beyond the confines of the classroom and laboratory into real life situations for their answers. A new point in the book is a group of additional questions and problems on each chapter, included in the Appendix. Another outstanding point of merit is the clarity and good proportion of most of the diagrams. The pictures are clear for the most part and are very representative of the point of view of the text.

In the opinion of the reviewer this is much more than a reference text, it is a most potent tool for the effective learning of the principles of physics.

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In point of criticism, one thing seems to be of significance. The authors have given little help toward the acquisition of the vocabulary of physics except for printing a large number of the uncommon words and phrases in bold-face type. While this same criticism may be launched against most of the physics texts, it is a point which should have the careful attention of the textbook writers. Recent studies would indicate that the technical vocabulary of physics which we force students to acquire in a period of ten months, is in itself a task of no mean proportion, and so devices to help the student in this mastery should be given attention.

—ELLSWORTH S. OBOURN.

The Terminology of Physical Science—1929—Duane Roller—115 pages—$1.00—University of Oklahoma Press, Norman, Okla.

It is the object of the author of this book to bring together in a few pages many of the troublesome aspects of the terminology of physical science and to suggest the proper or better usage. The book is divided into the following chapters:

PHYSICAL TERMS AND THEIR DEFINITIONS
COMMON PREFIXES AND SUFFIXES
THE NAMES OF THE CHEMICAL ELEMENTS
THE PRONUNCIATION OF WORDS USED IN SCIENCE
THE SPELLING OF WORDS USED IN SCIENCE
SIMPLER STANDARD ABBREVIATIONS

A large portion of the first half of the book is given over to Chapter I, which is an annotated glossary of terms which the author believes to be generally troublesome in physical science. In many cases the origin of the word is given and usually a short discussion of the meaning, with ample illustrations of its correct usage.

In the second chapter is given a list of the prefixes and suffixes more or less common to the literature of physical science. The prefix or suffix is stated, its meaning given, and a word or two illustrating its use. Forms from the Latin are marked, while all others are of Greek origin.

In Chapter III the author gives a list of the elements and a short discussion of each in a paragraph. This includes the origin of the term and the name of the discoverer.

Chapter IV deals with a list of over two hundred words commonly mispronounced in physical science. The word is given and after it a series of pronouncing keys which aid in giving the proper sound to the letters. The accent of all words is marked.

Chapter V deals with the proper spelling of words used in physical science. The first part deals with a word list for which a simplified spelling is accepted. The old and new forms are both given. A second list deals with the preferred plural forms. The singular of the word is given, the preferred plural and, in some cases, an accepted plural.

Chapter VI is devoted to a list of simpler abbreviations for many of the commonly used terms in physical science.

This little book without doubt has merit in that it is a scholarly product from a scholar in the field of physical science.

A clear statement of the possible uses of the book is lacking, but at several points the author implies that it will find a use in the high school classroom. One would doubt his familiarity with the vocabulary of high school science upon the inclusion of such terms as: athermonous and diathermonous; angular momentum; selective dispersion; scalars; undulatory, etc.

With no statement from the author, one wonders to what extent other than opinion the words included in the various parts of the book have objectivity with respect to text books and other publications

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on the level of the high school student. If the author has made use of the studies and published word lists* in the field of high school science, no reference is given to them in the book.

The book will find a use in the hands of textbook writers and in the hands of teachers or persons who are reading in the field of advanced science, and to some extent for high school students, especially with regard to Chapter III on "The Names of the Chemical Elements.

—ELLSWORTH S. OBOURN.

A Collection of Chemical Lecture Experiments—1926—H. F. Davison, Assistant Professor of Chemistry, Brown University—139 pages—$2.50—The Chemical Catalog Company, New York.

When a chemistry teacher is suddenly called upon to give a talk to the Science Club, he is often at a loss to select from his experiences an experiment both appropriate and unique. Likewise, students often wish suggestions and directions for demonstrations which they propose to perform before a club. The instructor must supply the inspiration forthwith.

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The table of contents groups the experiments under ten headings. While this classification is arbitrary—consisting of a rationalization rather than a plan,—nevertheless, any teacher of chemistry should find in this little volume enough suggestions to give it a place on his bookshelf.

—R. E. HORTON.

Industrial Chemistry—1928—An elementary treatise for the student and general reader—Emil Raymond Riegel, Ph.D., Professor of Physical and Industrial Chemistry, University of Buffalo—634 pages—$9.00—Chemical Catalog Company, New York.

Two purposes motivated the author in presenting this book to the public. *One*, ". . . to present in a single volume a faithful picture of the numerous activities which make up industrial chemistry." course such as is usually given to undergraduates in our colleges and *Two*, ". . . to offer a classroom text in the industrial chemistry course such as is usually given to undergraduate in our colleges and technical schools."

In examining a work of this kind one naturally estimates it in terms of his experience with other books of like purpose, and in terms of its probable usefulness in its field. Satisfactory texts for introductory courses in Industrial Chemistry are not too plentiful. The three or four works with which the writer is familiar have very definite limitations. Several of the older ones are collaborations,

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* Word lists and vocabulary studies in science:
(a) The Technical Vocabulary of: General Science, Biology, Chemistry, Physics, Geography, Physiology—Luella C. Pressey—Public School Publishing Co., Bloomington, Ill.
(b) The Vocabularies of High School Science Text Books—S. R. Powers—Teachers College Record, Vol. 26, 368-382—Jan. 1925—Bureau of Publications, Teachers College, Columbia University, New York City.
(c) A Vocabulary of Scientific Terms for High School Students—S. R. Powers—Teachers College Record, Nov. 1926—Bureau of Publications, Teachers College, Columbia University, New York City.
(d) Classical Origin of Scientific Terms—Lodge—Latin Notes Supplement, No. 26, Nov. 1927—Service Bureau for Classical Teachers 525 West 120th Street, New York City.

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There are fifty units in the book, organized into chapters having no logical sequence as a whole, but so arranged that related fields are together. Of these units the first thirty-nine present each a definite field of industry, beginning with sulphuric acid and continuing through the heavy chemicals, cement, glass, fertilizers, dry distillation, furnace practice, industrial gases, fermentations, paper, rayon, dyes, paints, soaps, rubber, explosives, and the other common divisions of industrial products and practices. Chapters 40 through 46 take up patents, commercial appliances, materials and instruments of control. The closing chapters deal with metallurgy of the important commercial metals, and the final one covers the precious and rare metals. Modern practices are stressed throughout. The omission of food industries, electroplating, sulphur, the Goldschmidt's or thermite reactions, are among the few which occur to me as exceptions to the general completeness. Thus the selection of material and its organization are features which recommend the book.

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Altogether, it seems that the purposes set forth by Prof. Rieger have been achieved by the book. There is a need for such a volume and it ought to find a field of usefulness and a ready sale.

—R. E. HORTON.

Educational Biology—1930—Eikenberry, W. L., and Waldron, R. A.—549 pages—illustrated—glossary—Ginn & Company.

The favor that educational biology is gaining in educational institutions is shown by the numerous texts appearing in the subject. This text is written for first-year college students. The authors stress the function and place of science in a world made new by scientific discoveries and invention, emphasizing the influence of biological facts, discoveries and applications in making this a "new" world. The expressed aims are: (1) to furnish a biological foundation for teaching; (2) to furnish a better understanding of the human organism; (3) to study the relation of biology to modern social life; and (4) to inspire students to the exploration of new fields of knowledge.

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—C. W. F.

The Supervision of Secondary Subjects—1929—Edited by W. L. Uhl—D. Appleton and Company.

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The Supervision of Elementary Subjects—1929—Edited by W. H. Burton—D. Appleton & Co.

Chapter X (pages 484-517), The Supervision of Nature Study, is written by Professor Elliot R. Downing. "Under curriculum construction" we find a discussion of the major goals, specific objectives, knowledge and mastery of principles, pupil activities to accomplish objectives, and samples of curricula. Other topics treated are methods of teaching, tests, and equipment.

Chapter XIV is on health education and physical education (pages 622-697). It covers aims, health service, administration of school plant, health survey, major problems and objectives; the physical education program, measurements of results and points in good teaching in physical education.

Public Health and Hygiene—1929—C. F. Bolduan, M.D.—312 pages—122 illustrations—$2.75—W. B. Saunders Company.

This is a student's manual presenting the development and present status of facts and principles of public health and hygiene. A very interesting historical background is included. The important communicable diseases and preventable diseases are discussed. There are ten chapters on community and hygiene topics, besides graphs, tables, and a chapter on vital statistics.

Photographic Emulsions—1929—E. J. Wall—256 pages—42 illustrations—American Photographic Publishing Company, Boston.

Emulsion making has evidently been a hobby with the author of this book, and the record of his long experience will be a great help to others who are inclined to undertake this fascinating pastime. There are thirteen chapters which describe the workroom, materials, various tables of emulsions for negatives and paper, mixing emulsions, coating plates, films and paper, drying, and new formulas.

The Fields and Methods of Knowledge—1929—R. F. Piper and P. W. Ward—438 pages—28 illustrations—Alfred A. Knopf, Inc.

"This book is a survey of the sciences and an analysis of scientific method." It is the outgrowth of experiments carried on in teaching a course in logic and orientation. In Part I, *A Survey of the Sciences*, the chapter titles are: background of knowledge; mathematics; physical sciences; biological science; psychology; history; the social sciences. Part II, *A Philosophy of Science*, discusses: thinking; observation; judgment and inference; induction; deduction; verification; discovery; statistical methods; organization of knowledge. Part III, *Other Philosophical Disciplines*, covers: ethics; esthetics; religion and metaphysics.

A Textbook of Anatomy and Physiology—3rd Edition—1929—Jesse F. Williams—578 pages—405 illustrations, including 29 in color—$2.75—W. B. Saunders Company.

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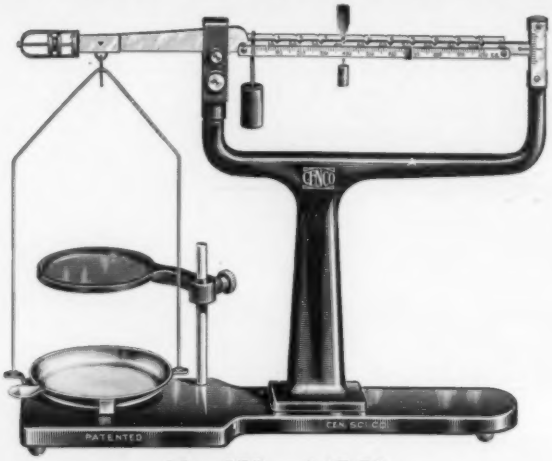

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Modern Cosmologies—1929—Hector Macpherson—131 pages—illustrated—$2.75—Oxford University Press.

This is a summary of observations and theories bearing on the problem of cosmologies. It treats of geocentric and heliocentric cosmologies; nineteenth and twentieth century thought and progress; the local cluster; status of nebulae; globular cluster; island universes.

Discoveries and Inventions—3rd edition—1930—Edward Cressy—476 pages—342 illustrations—$4.25—E. P. Dutton and Co., Inc.

This is a popular science book which treats of the achievements of science in non-technical language. It is suitable for any school reference library from the junior high level up. The topics covered are: water power; coal, gas and petroleum; steam power; gas and oil engines; generation of electricity; electric lighting and heating; foundry and forge; electric furnace; refrigeration; soil and crops; modern chemistry; railways; electric tractor; motor cars; modern ships; conquest of air; wireless; photography; radium, electricity and matter.

Soils and Soil Management—1929—C. E. Millar—477 pages—247 illustrations—Webb Book Company, St. Paul, Minnesota.

Problems which arise in actual life on the farm relating to the soil are analyzed here in a helpful way. The student is put into the position of the one who has a problem to solve. A few of the chapter titles are: Selecting a Farm; Classifying Soil; Good Tilth; Cultivating the Crop; Controlling Soil Moisture; Fertilizers; Building Up Soils; Studying Soil Life; Gardening; The Home Grounds. The chapters open with a statement of several problems. Laboratory and field studies are outlined. A helpful glossary is found at the end of the book.

General Metal Work—1930—Alfred B. Grayshon—206 pages—illustrated—$1.70—D. Van Nostrand Company, Inc.

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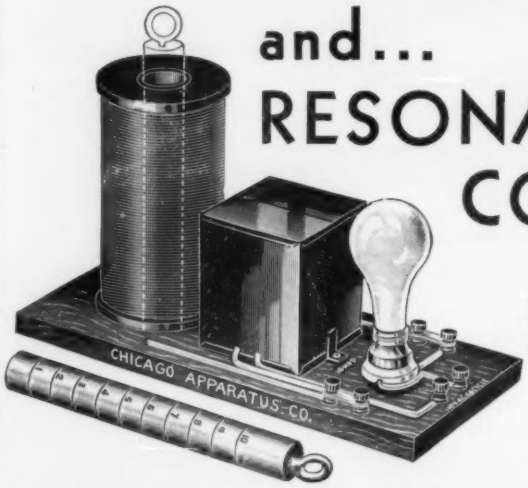

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Nov. 1925, "Through the Ages of Time"
Jan. 1927, "Why Airplanes Go Up"
Nov. 1927, "Scientific Explanations" (Sound), and "The Cabin of Sound"
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John Wesley Among the Scientists—1928—Frank W. Collier—351 pages—$2.00—The Abingdon Press.

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High School Science Terminology; Chemistry and Physics—1930—J. O. Frank and H. K. White—203 pages—$2.50.—J. O. Frank and Sons, Oshkosh, Wisconsin.

When, as these authors point out, teachers find in modern high school chemistry texts sixteen different definitions for *valence*, it seems high time that there should be some standard work on definitions of science terms, written at the high school level. We believe you will find use for this book in your personal and the science department library.

Research and Medical Progress and Other Addresses—1929—J. Shelton Horsley, M.D.—208 pages—$2.00—C. V. Mosby Company.

This is a book primarily for the physician, nurse, and medical student. It covers general research, modern surgery, the ideals of the surgeon, stomach trouble, ulcers and cancer, and the medical profession.

Diabetic Manual for Patients—1928—Henry J. John—202 pages—42 illustrations—$2.00—C. R. Mosby Co., St. Louis.

This manual explains the causes of diabetes and gives directions by which a patient may care for himself and lead a comfortable, normal life. Many menus and recipes for the diabetic patient are given.

How to Letter—1928—M. L. Heller—64 pages—$1.00—Bridgeman, publisher, Pelham, New York.

This book contains a series of progressive lessons on lettering and the designing of cards suitable for high school students. One can easily use the book for self-instruction.

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Prizes of $50—$10 are offered to teachers for detailed lesson plans and outline or how American Forest and Forest Life can best be used in the schools. Contest closes June 1, 1930. For further particulars address American Forest and Forest Life, 1523 L Street N. W., Washington, D. C.

The Women's Christian Temperance Union offers prizes of $50—$25 for essays, sample lessons and posters. Contest closes June 30, 1930. For particulars, send to director, Cora Frances Stoddard, 400 Boylston Street, Boston, Massachusetts.

WHAT TO MAKE

A Home-made Voltmeter. Pop. Sci. Mo., 116:1:67, Jan., 1930.
Lead Trees Grown in Gels. Jo. Chem. Ed., 6:2228, Dec., 1929.
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